AVIATION
AND
AERONAUTICAL ENGINEERING

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VOLUME III
Number 12

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SPECIAL FEATURES

THEORY OF BOMB DROPPING
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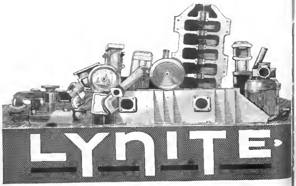

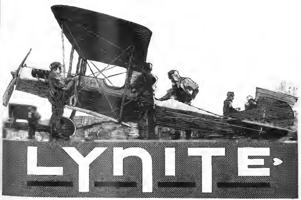

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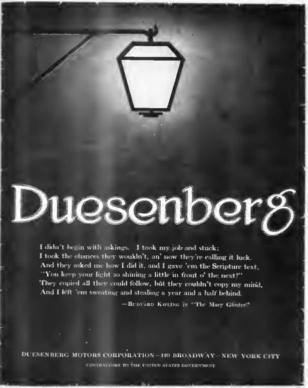

Duesenberg

I didn't begin with askings. I took my job and stuck;
I took the chances they wouldn't, an' now they're calling it luck.
And they asked me how I did it, and I gave 'em the Scripture text,
"You keep your light so shining a little in front o' the next!"
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—Rudyard Kipling in "The Mary Gloster"

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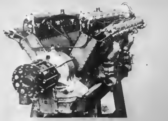

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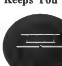
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Vol III January 15, 1918 No 12

Theory of Bomb Dropping*

When any object such as a bomb is allowed to fall from an aircraft in flight, it will not drop vertically, but its path will be a definite curved line. If the fall took place in a vacuum the curve would be a parabola. The path, however, is influenced by various factors, particularly the resistance of the air, so that it becomes a distorted parabola or curve of higher order.

For the theoretical determination of this curve we must know first the velocity of the aircraft relative to the earth and the height from which the fall begins. Furthermore, we must know the form of the bomb, its weight and the atmospheric pressure prevailing throughout the path of fall.

These many variables would make the computation very difficult if we did not make such assumptions as the following. The bomb is always freely released, and not thrown. The release always occurs at a moment when the aircraft is in exactly horizontal flight. Finally, the atmospheric pressure may be assumed constant.

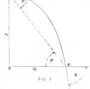

Fig 1

Assume a particle of matter upon which a force acts, imparting a velocity v, making the angle α with the horizontal at the instant when the time $t = 0$. The effect of gravity is to impart an acceleration g in the vertical direction and the motion of the particle therefore becomes the resultant of a uniform and a uniformly accelerated velocity. The equation of the path becomes

$$y = x \tan\alpha - \frac{g}{2v^2}\,\frac{x^2}{\cos^2\alpha} \tag{1}$$

This is the equation of a parabola and represents the path neglecting the resistance of the air. If now we wish to find the curve which the body will describe when freely released, set the angle α equal to zero on the supposition that the airplane was in horizontal flight. Equation (1) becomes

$$y = \frac{g}{2v^2}\,x^2 \tag{2}$$

In Fig. 1 such a trajectory is represented in which A is the point of release at the altitude y above the ground and C the point of striking the ground at a horizontal distance $x = BC$ from the point B.

The elements of interest of this trajectory follow:

1. The horizontal projection $BC = x$ of the parabola, i.e., the distance covered in a horizontal direction.
2. The final velocity v_e with which the projectile reaches the ground.
3. The time of fall.
4. The angle ε at which the projectile strikes.

From equation (2) we obtain for x

$$x = v\sqrt{\frac{2y}{g}} \tag{3}$$

The time of fall is obtained from

$$t = \sqrt{\frac{2y}{g}} \tag{4}$$

From this equation it is evident that the time of fall theoretically is dependent only on the height and not on the velocity.

The final velocity is computed from the equation $v_e^2 = v^2 + g^2t^2$ or substituting from (4)

$$v_e = \sqrt{v^2 + 2gy} \tag{5}$$

The angle of fall is computed from

$$\tan\varepsilon = \frac{1}{v}\sqrt{2gy} \tag{6}$$

Fig. 2

If we designate the angle which the line AC makes with the horizontal as φ, then it is easily seen that the bomb must be released at the instant when the target appears at this angle below the horizontal.

The angle is computed from the equation $\tan\varphi = y/x$; x is unknown. Substitute for x its value from equation (3) and

$$\tan\varphi = \frac{1}{v}\sqrt{\frac{gy}{2}} \tag{7}$$

We have now expressed this sighting angle in terms of the velocity over the ground and the altitude.

If reality agreed with the above simple assumptions of a vacuum and a particle of matter, it would be easy to outline the general principles for a sighting mechanism for bomb dropping.

Equations (6) and (7) yield

$$\tan\varepsilon = 2\tan\varphi \tag{8}$$

From equation (7) the sighting mechanism could be arranged as shown in Fig. 2. We may write

$$\tan\varphi = \frac{\sqrt{\frac{gy}{2}}}{v}$$

The sighting tube AC is connected with the horizontal scale BC and the vertical scale AB, and A and C can be moved along their respective scales. Upon the horizontal scale the different velocities of the aircraft are laid off. The vertical scale is proportional to the expression $\sqrt{\frac{gy}{2}}$ and the point A is accordingly set to the altitude of the machine.

For exact computations other factors than the resistance of the air must be considered, particularly the form and weight of the projectile, and the decrease in density of the air with higher altitude. Up to heights of 500 to 600 meters and velocities of 35 m/sec., the effect of air resistance upon the horizontal distance x is very limited and x can be computed by the equation (3).

In the dropping of bombs from an aircraft in flight one is above everything else dependent upon an exact knowledge of the altitude and velocity over the ground. It then becomes of

---

* By Ernst Heinkel. Abstracts from *Zeitschrift für Flugtechnik*, by E. J. Gayhart

importance to investigate the effect upon the accuracy of hitting of errors in the height or velocity or both.

If we designate the distance from point of aim to the point struck as dx, the error in height as dy and the error in velocity as dv_s, then differentiation of the equation

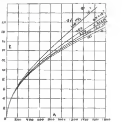

Fig. 3

$$x = \sqrt{\frac{2}{g}}\, v_s \sqrt{y}$$

yields

$$\frac{dx}{x} = \frac{dv_s}{v_s} + \frac{dy}{2y}$$

If we write $dv_s = av_s$, $dy = by$, then the factor a is the error in altitude and b the error in velocity, and the above equation becomes

$$\frac{dx}{x} = a + \frac{b}{2}$$

or substituting for x the value from a previous equation,

$$dx = \sqrt{\frac{2}{g}}\, v_s \sqrt{y}\left(a + \frac{b}{2}\right) \qquad (9)$$

From the above equation it is to be seen that the error in hitting the target is proportional to the product of the velocity of the aircraft and the square root of its altitude.

A further source of error is to be found in the probability that at the moment of release, the airplane is not in exactly horizontal flight. The angle of deviation from the horizontal will be in general a small angle and the error from this source in comparison with the deviation from the other sources will be very small.

The problem of the resistance of the air appears at first sight to be very complicated. Really, the error due to the resistance of the air depends in addition to the altitude only on the relative velocity of the aircraft through the medium. One may understand the question better if the motion is considered as resolved in two components. A small error is introduced here but with the limited horizontal velocity it is very small and does not affect the explanation of the problem.

Let us assume at first homogeneous atmosphere. We have two components of resistance to consider, the horizontal and the vertical. Both induce errors of opposite sign, so that the paradox may arise that because of resistance, the bomb will travel farther in the air than if in a vacuum.

First consider the resistance in the vertical direction. For the velocities of fall coming under consideration, we may assume with sufficient accuracy that the resistance varies as the square of the velocity.

If W equals the weight of the body, and α, a coefficient dependent upon its surface and form, then

$$\frac{W}{g} \cdot \frac{dv}{dt} = W - \alpha v^2$$

If we designate the limiting velocity where the resistance equals the weight and the acceleration zero, as v_{s1}, then $W = \alpha v_{s1}^2$, and $\alpha = W v_{s1}^{-2}$.

For the sake of simplicity let us write

$$\frac{\alpha \cdot g}{W} = a = g\, v_{s1}^{-2}$$

Development of the above equation yields

$$g\,\frac{dt}{dv} = \frac{1}{1-\left(\frac{v}{v_{s1}}\right)^2}$$

and through integration,

$$t = \frac{1}{g}\int \frac{dv}{1-\left(\frac{v}{v_{s1}}\right)^2} + C = \frac{v_{s1}}{2g}\log\frac{v_{s1}+v}{v_{s1}-v}$$

Solving this equation for v gives

$$v = v_{s1}\,\frac{e^{\frac{2gt}{v_{s1}}}-1}{e^{\frac{2gt}{v_{s1}}}+1}$$

Now $v = \frac{dh}{dt}$ and in consequence

$$h = v_{s1}\int \frac{e^{\frac{2gt}{v_{s1}}}-1}{e^{\frac{2gt}{v_{s1}}}+1}\,dt + C$$

Integration gives

$$h = \frac{v_{s1}^2}{g}\left\{\log\left(e^{\frac{2gt}{v_{s1}}}+1\right) - \frac{gt}{v_{s1}}\right\} + C$$

Since for $t = 0$, $h = 0$,

$$C = -\frac{v_{s1}^2}{g}\log 2$$

$$\text{and } h = \frac{1}{a}\left\{\log\frac{e^{2av_{s1}t}+1}{2} - a\,v_{s1}\,t\right\}$$

In Fig. 4 curves of height against time are shown for various values of a and v_{s1}, and for comparison the curve is shown for fall in a vacuum.

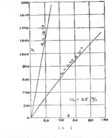

Fig. 4

We may assume that with a regular form, α for the horizontal component will have the same value. For the derivation of the horizontal resistance we must consider that this resistance is a maximum at the moment of release and varies as the square of the velocity. It is clear that by this velocity is meant not the speed over the ground but the velocity through the medium. For the sake of simplicity, we can therefore state the problem as if the body fell from a fixed point and was driven by a wind of the same velocity.

If we designate the velocity of the aircraft through the air as v, then $\frac{W}{g}\frac{dv}{dt} = \alpha(v_s - v)^2$ and $\frac{dv}{dt} = a(v_s - v)^2$

$$\text{Then } t = \frac{1}{a}\int_0^v \frac{dv}{(v_s - v)^2} = \frac{1}{a(v_s - v)} + C$$

$$\text{and thence } t = \frac{1}{a(v_s - v)} - \frac{1}{a v_s}$$

This equation solved for v gives

$$v = v_s - \frac{1}{a\left(t + \frac{1}{a v_s}\right)}$$

Further, if we designate the error as s

$$ds = v_s\,dt - \frac{dt}{a\left(t + \frac{1}{a v_s}\right)}$$

and s becomes

$$s = v_s t - \frac{1}{a}\log(1 + a v_s t)$$

This expression may be developed in a series. In Fig. 4 different values of s are shown in a diagram.

This value of s holds for machines of pusher type. For tractor machines the influence of the propeller is to be noted since the bomb receives a further acceleration to the rear in the first half second.

If we designate the velocity imparted by the propeller stream with A, then $v = v_s - \frac{1}{a\left(t + \frac{1}{a(v_s - A)}\right)}$

$$\text{and } s = v_s t - \frac{1}{a}\log\left\{1 + a\,t\,(v_s - A)\right\}$$

We come now to an investigation as to the influence of the air resistance upon the sighting angle. If we designate the

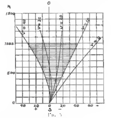

Fig. 5

velocity over the ground by v and the time of fall in vacuum by τ, then

$$\tan\varphi = \frac{v\tau}{h}$$

and in air filled space

$$\tan\varphi' = \frac{vt - s}{h}$$

$$\text{and } \Delta\tan\varphi = \frac{v(\tau - t) + s}{h}$$

$$= \frac{v(\tau - t) + v_s t - \frac{1}{a}\log(1 + a v_s t)}{h}$$

Observation of this equation shows that $\Delta\tan\varphi$ may be either negative or positive. It is negative when $vt - s > v\tau$. This case occurs when the expression $(v - v_s)$ is positive, i.e., when the aircraft flies with the wind.

In Fig. 5 the range of the error is shown graphically for different wind velocities. The shaded area shows the difference in error to be expected between a head wind and opposing wind of 15 meters per second.

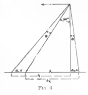

Fig. 6

Heretofore, the atmosphere has been considered as homogeneous. This is not the case since a falling body is continually passing from a rarer to a denser medium, so that the resistance α reaches its full value α_0 only at the surface of the earth. The following equation may be set up

$$\alpha = \alpha_0\,\frac{b_n + b_{n-1} + \ldots + b_0}{b_0\,(n+1)}$$

where α_0 holds for $h = 0$, and b equals the barometer reading for the respective heights. Here we have the relation

$$h_n \quad h_{n-1} \cdots\cdots h_1 = 1\left(\frac{n-1}{n}\right) \cdots \left(\frac{1}{n}\right)^7$$

Since, however, for an altitude of 1000 m., the quotient of $\frac{h}{h_0}$ is always equal to 0.88 it follows that the influence of the change in density of the air may be neglected.

Of all errors which are made in dropping bombs, the most dangerous is that due to acceleration, and since it is often overlooked, let us examine it more closely.

Let v = velocity of the aircraft
h = altitude
s = horizontal distance covered
a = the derivative $\frac{dv}{dt}$ or acceleration

The acceleration error manifests itself in several ways. In

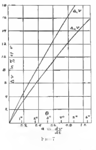

Fig. 7

one way, in the measurement of the velocity when the velocity is measured incorrectly, since, because of the accelera-

tion, the direction of gravity is swung through an angle equal to $\tan^{-1}\frac{a}{g}$. Here, only the error that arises from this deviation should be discussed, and the incidental error in velocity which is usually small be considered later. For that reason in the first case, only the relation should be given between incorrect measurement in consequence of acceleration and acceleration itself.

$$\Delta s = s - s' = h\left[\tan\varphi - \frac{\tan\varphi - \frac{a}{g}}{1 + \frac{a}{g}\cdot\tan\varphi}\right]$$

$$\tan\varphi = \frac{0.452\, v\sqrt{h}}{h} \quad (0.452 = \sqrt{2/g} = \sqrt{2/9.81})$$

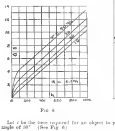

Fig 8

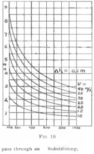

Fig 10

Fig 9

Let t be the time required for an object to pass through an angle of 30° (See Fig 6)

$s = v_1 t_1 = v_2 t_2$, and $s_1 = v t_1$, $s_2 = v t_2$

Thence $\Delta_1 s = \Delta_1 v\, t$ and $\Delta_2 s = \Delta_2 v\, t$

In general $\Delta v = \frac{\Delta s}{t}$

$s = h \tan 30°$

$s_1 = h \tan(30° + \theta)$ and $s_2 = h(\tan 30° + \tan\theta)$ and thence $\Delta_1 s = h[\tan(30° + \theta) - \tan 30°]$, and $\Delta_2 s = h\tan\theta$, and further $t = \frac{s}{v} = \frac{h\tan(30° + \theta)}{v}$

$$t_2 = \frac{s_2}{v} = \frac{h(\tan 30° + \tan\theta)}{v}$$

Substituting above

$$\Delta_1 v = v\left[1 - \frac{\tan 30°}{\tan(30° + \theta)}\right]$$

$\Delta_2 v$ [illegible] $\tan 30° + \frac{a}{g}$

This shows that the resulting error in velocity is dependent only on the velocity and its acceleration. In Fig. 7 this error is expressed in per cent of velocity for various accelerations.

An acceleration at the moment of release causes an error of some magnitude, since through it, the sighting angle φ is changed, because the direction of travel is turned through the angle $\tan^{-1}\frac{a}{g}$.

We have $s = h\tan\varphi$

and $s' = h\tan\left(\varphi - \tan^{-1}\frac{a}{g}\right)$

Substituting,

$$\Delta s = a\sqrt{h}\,\frac{h + 0.204\, v^2}{9.81\sqrt{h} + 0.452\, v\, a}$$

This error for an acceleration of 0.1 meter is shown in Fig. 8

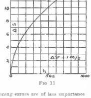

Fig 11

The remaining errors are of less importance. They are the following:

1 The steering error of the pilot, the effect of which is shown in Fig. 9

2 The errors induced by incorrect altitudes and velocities shown in Figs. 10 and 11 and previously discussed

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Seaplane Float Construction

Second Installment

By Charles G. MacGregor

Curtiss Aeroplane and Motor Corp

Deck Edge Stringers.—These are constructed similar to the chine stringers and are fitted to the deck edge of the flat backs.

The materials used in the chine and deck edge stringers are ash, white oak, elm, mahogany.

Body Molds.—Where bent frame construction is used it is necessary to construct and erect temporary molds or forms to give the shape of the float. These are usually built of rough lumber similar to the keel mold, with stout straps across the back. Two types are shown in Figs. 10-11. The outside edge is cut to the inside of the fairing ribbands. They are set on top of the bottom stringers or keelsons after these are fixed in position. The fastenings used in the construction of the molds are wood screws (not wire nails), so that when the framework is completed they can be taken apart without breakage, removed from the interior of the framework and be reassembled for future use.

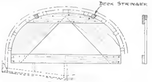


Fig. 10 Open Mold

Deck Stringers.—All stringers which run inside the frames are fitted before the frames are bent over the ribbands, and are riveted to the frames where possible. Where intercostal stringers, or stringers fitted in short lengths between the frames, are fitted a ribband is let into the mold for this stringer to rest upon. This intercostal is only fitted after the frames are in place and is intended to prevent the planking from caving in or dishing where the frame spacing is wide (Fig. 7).

Materials used are ash, oak, elm, mahogany, Port Orford cedar, white pine and spruce.

Fairing Ribbands.—When the molds are set up on the round-back type of construction, temporary stringers or ribbands are laid longitudinally outside of these spaced about 4 in. apart. The frames are bent over these, then when the framework is complete and before the seam patterns are put on, the water-tight bulkheads are put in, the ribbands being cut on each side of the bulkheads to allow this. The ribbands are fastened to each mold by one stout wood screw. Particular attention is paid to the "fairing" of the ribbands and the molds, so that there will be no humps or hollows either transversely or longitudinally.

The method of fairing is as follows: Stand away from either end of the float a distance of about 3 or 4 ft. and glance along each ribband on the top edge. They should not show any unevenness. Should there be any appearance of a hollow slacken the screw that holds it to the mold until this hollowness disappears, then drive a shim or wedge in between the ribband and the mold. If there should be any appearance of roundness, slacken the screw, or better still, take it out altogether, and saw or chisel a piece off the mold at this point, replace the screw and try again. Although all these ribbands may appear to be perfectly fair longitudinally, they may not be transversely. To test this bend several thin flat splines across the back of the float, tacked lightly to the ribbands. Now glance at these end on and look for any unevenness in their curvature, observing at the same time that each spline touches every ribband. It is important that they should be correct. The ribbands are not removed from the molds until each is overtaken by the planks as they are fitted.

The materials used are oak, ash, Oregon pine and yellow pine.

Frames.—These are of two types, viz., the steam bent and the solid frame. The former is used in the roundbacks (Fig. 5), and the latter on the flatbacks (Figs. 6-7). The heels of all bent frames or ribs, as they are sometimes called, are strapped or shod with light sheet copper, so that the rivet or screw fastening through the end will not split it. The nail heads in the copper are soldered so that they will not work loose and drop out. The corners on the inside of the curve of the frames are chamfered so as to eliminate to some extent the possibility of splitting when the wood is compressed with the bending. The frame is much stiffer when bent on edge than when it is bent on the flat. The thinnest frame that will hold a plank fastening is 3/8 in., but 7/16 in. more satisfactory for through riveting, because when the hole is drilled for the rivet almost a quarter of the cross section of the frame is cut away.

The built frames are made up in three parts (Fig. 8), fitted to the inside of the planking all around, and where seam battens are used, a notch is cut in the outer edge into which these fit. The names of the different parts of the frame are: The top piece is known as the beam, the side pieces are the side frames and the bottom piece is the floor. Each frame is built complete before it is set upon the keel and keel mold. The corner joint is mortised. The depth of the mortise does not exceed one-third of the thickness of the frame. At the corners the frames are made wider to make up for what is cut out of them by the deck and chine stringers and the mortise and also to give more surface at the joint for riveting. These joints are the weakest parts of the whole frame, so great care is taken to have them fit well and to see that the wood is not split when riveting the parts together. Figure 6 shows the joint. The best fastening for this part is the brass tubular rivet; it holds well and is easily riveted. Small knees of laminated wood are often used to brace the corners at the deck edge and chines (Fig. 8).

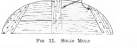


Fig. 11. Solid Mold

The materials used for bent frames are ash, oak and elm; for solid frames, ash, oak, mahogany and Spanish cedar.

Bulkheads.—Floats are divided into watertight compartments by transverse bulkheads or partitions; each bulkhead is strong enough to withstand the pressure against it from one side should the water fill the compartment on the other side of it. Each bulkhead is built of two layers of wood with cloth and marine glue or varnish between them. The grain of each skin crosses the other at an angle of 90 deg., and the skins are through fastened with solid brass or copper rivets. Along the edge of the bulkhead a hardwood frame is usually bent and through riveted to it. The bulkhead is also stiffened vertically and horizontally to prevent it from bulging under pressure; this also prevents straining of the edge fastenings. The bulkhead stiffeners are more efficient on edge than when placed on the flat. When the keelson or a stringer passes through the bulkhead the edge around the hole is supported by small strips or blocks, and are also necessary to keep this part watertight. Laminated wood under various trade names

is used extensively for bulkheads, but unfortunately it is most difficult to obtain in this country. This wood is known as three-ply lamination or veneer

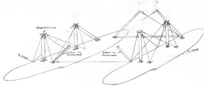


Fig. 12 Single Center Struts

The materials used besides the three-ply are mahogany, Spanish cedar, white cedar, white pine and spruce. Each plank does not exceed 5 in. in width and is not less than 1/16 in. thick

Seam Strips—The edges of all planks between the frames in the single skin construction must be supported in some way inside. The method adopted in float construction is by means of thin strips of hardwood run over the outside of the frames in a longitudinal direction, and placed so that each will come directly under the plank seam. These strips are fastened to each frame by one wood screw. The ends of each strip are notched into the stem and sternpost (Fig. 6)

Between these strips and on the outside edge of each frame is nailed a strip of wood called a liner. This is intended to fill in the space that would otherwise be left between the frame and the planking. These are usually made of pine. The materials used for the seam battens are oak, ash, elm, Spanish cedar and spruce

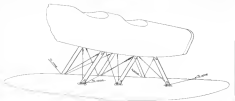


Fig. 13 Double Side Struts

Doublings—Where a hole is cut through the deck or planking for handholes, struts or drainplugs, this part is weakened thereby, and is reinforced by what are known as doublings or blocking made of hardwood. These are attached to the frames, stringers, etc., where possible. They are fitted under the planking at the point where a fitting is attached or passes through, to make up sufficient thickness into which the fastenings are put. Doublings are illustrated in Fig. 7. The materials used for the doublings are ash, oak and mahogany

Struts and Braces—Here we have about the most difficult parts to construct in the whole float. This is a subject that is too extensive to enlarge upon in this article, because there are so many different methods of bracing or hanging the floats from the machine. So we had better limit this to a very brief outline of some of the commoner of these methods.

The continuation of the struts from the fuselage inside the float is distributed over the bottom structure, so that no strain due to landing comes on the topsides

The outer struts are of three distinct types, as shown in Figs. 12, 13 and 14. Fig. 12, Single Center Struts, Fig. 13, Double Side Struts, Fig. 14, "A" Struts. These, of course, have diagonal wires and braces. The weight of the machine is distributed over the length of the float as much as possible. Two or three points of support are found to be sufficient, and are the most practicable in the floats in present day use. The foremost of these struts is known as the landing strut, it is set diagonally to resist the impacts of the water on the forward bottom of the float when taxiing or landing. The intermediate struts take the greatest load and the rear struts take the least except when the machine pancakes or lands on the water tail first.

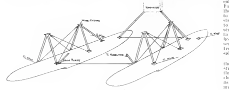


Fig. 14 "A" Struts

From the point of attachment of these struts on the top of the float to the bottom keelsons, etc., other struts radiate inside, and are bolted to the metal clips inside, which have studs extending up through the deck to which the outside strut sockets are bolted. The heads of these studs are secured on the inside to prevent them from turning. All nuts on the outside are castellated

In the use of steel struts inside, the point of attachment to the outer struts is kept as close as possible to the deck, and the inner struts as close up to the underside of the deck as possible so that there is not too much length left unsupported between these points. All strut pieces

are fitted athwartship so that this will give a little latitude for setting up, and allow the machine to swing forward or backward for final and finer adjustment. The deckplates are fitted snugly around the strut ends where they project through the deck, so that the packing can be put between them and the deck and the strut, thus insuring a watertight connection

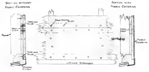


Fig. 15 Single Skin

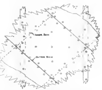


Fig. 17 Double Skin, Both Diagonal

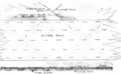


Fig. 19 Saunders Sewn System

Brace wires are not attached to the deckplates unless the inside structure is sufficiently strong and well bolted to them to stand the pull that will come on the wire.

On the flatbacks where single struts are used the struts are attached to the sides or to a cross bulkhead (Fig. 6) and are braced from there down to the keelson and chine stringers inside. Between them a good husky brace is fitted to take compression, and on the outside a strap is fitted to prevent spreading.

With the two point support (Fig. 6), the front struts act as landing and supporting members. The heel of the front is well forward and the heel of the rear strut is well aft, thus making each diagonally opposite

The fitting of the interior float struts is one of the most difficult tasks undertaken by the float builder and it requires the most careful and skillful workmanship

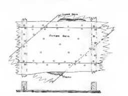


Fig. 16 Double Skin Diagonal and Fore-and-Aft

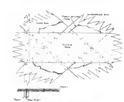


Fig. 18 Treble Skin

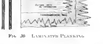


Fig. 20 Laminated Planking

Planking—There is a wide choice of methods of planking, but for good all around service the double skin diagonal is the most serviceable and durable.

Planks under 1/4 in. thick should never exceed 6 in. in width, and under 1/8 in. thick should never exceed 4 in. in width. If made greater than these widths they are very liable to check and split with the constant wetting and drying to which they are subjected under service conditions. Each plank is made in one length where possible, because each butt or joint is likely to be a weak point and means the addition of more weight to the float. When drilling holes for the fastenings in very thin planking a countersunk is not necessary for the head of the fastening, as it draws in flush when it is riveted, particularly in the soft woods

The following are brief descriptions of some of the methods of planking most commonly used and proved to be very satisfactory in actual service. These are divided into groups for location, and are further subdivided into types, as follows:

GROUP 1 TOPSIDE PLANKING

A, Single Skin with Seam Strips.
B, Single Skin with Seam Strips—Fabric covered
C, Double Skin Inner Diagonal, Outer Fore and Aft—Fabric between
D, Double Skin Inner Diagonal, Outer Diagonally opposite—Fabric between
E, Three Ply Laminated Wood

GROUP 2 BOTTOM PLANKING

A, Single Skin with Seam Strips
B, Double Skin Inner Skin Diagonal, Outer Skin Fore and Aft—Fabric between
C, Double Skin Inner Skin Diagonal Outer Skin Diagonally opposite—Fabric between
D, Treble Skin, Inner Diagonal Intermediate Diagonally opposite Outer Fore and Aft—Fabric between all skins
E, Three Ply Laminated Wood.

GROUP 3 BULKHEADS

A, Three Ply Laminated Wood
B, Double Skin, Inner Diagonal, Outer Diagonally opposite—Fabric between

Each group will now be treated individually and a brief description of the methods of planking some of the troubles met with and what to look out for during the various operations

GROUP 1 A, Single Skin with Seam Strips (Fig 15) This method is used mostly on the topsides of the flatbacks without any covering other than the varnish or the paint Most of the planks are straight or have a very slight curvature on the edges. Before the plank is fixed down a strip of tape or canvas saturated with marine glue or copal varnish is laid along the seam strips and rabbets below the edges of all planks so as to make the joint watertight The fastenings are spaced about $1\frac{1}{2}$ in apart on the seam strips and about 2 in apart on the frames. They are not less than ¼ in in from the edge of the plank Fastenings are staggered where possible to avoid the chances of the wood splitting between them When turning over the point of the rivet on the inside of the seam strip, each is turned to the right and left alternately for the same reason as stated above The heads are filed flush when finishing the planking on the outside

GROUP 1 B, Single Skin with Seam Strips, Fabric covered (Fig 15) The only difference between this type of planking and the preceding one is that tape and glue are not used under the plank seams, as the fabric which is stretched over the outside of the planking keeps it all watertight (See "Fabric Covering")

GROUP 1 C, Double Skin Diagonal and Fore and Aft—Fabric between (Fig 16) This method of planking is one of the strongest, and is used in both topside and bottom construction The inner skin is in narrow strips about 4 in wide, run from the keel out and forward to the chines at an angle of about 45 deg These planks are fastened at intervals to the frames, etc Sometimes they are run right across the bottom from chine to chine in one piece without being cut at the keel When used in topsides construction they are laid continuously across the back from chine to chine After the whole of the inner skin is completed, the fabric is then stretched over it as described under "Fabric Covering." and on it the seams of the under skin are marked with soft pencil, so that they can be easily located when drilling the holes for the fastenings on the outer skin The outer skin runs in a longitudinal or fore and aft direction The fastenings are arranged as shown in diagram It will be noticed that they are staggered for both inner and outer skins. When drilling these holes for the fastenings, a metal jig is made for one frame space, this will work in for most of the frame spaces and will facilitate the work The plank widths are kept as uniform as practicable, as this simplifies the work considerably The bottom planking can quite profitably be built up on a form or mold the exact shape of the bottom of the float On this form all keelsons, floors, etc, are marked The inner skin is laid first and tacked at the outer ends only, which should be left about ½ in longer than required The fabric is stretched over, the outer skin laid and all the fastenings are driven right through The whole is then lifted off the mold, turned over and the ends of the rivets are turned down The bottom planking is now placed on the upturned float bottom, fitted between chines and finally screw fastened to the floors and stringers This method of building the bottom planking is found to be the best, because if the planking is built right on to the float bottom, trouble will be experienced in riveting the fastenings on the inside; in fact, in certain float construction it is almost impossible to build with rivet fastenings, and wood screws have to be resorted to for fastenings. When single topside planking is used, one or two of the planks are left off for access of the arm when riveting the bottom, and are screwed on when the planking is completed

GROUPS 1 D, 2-C, 3-B, Double skin, both diagonal (Fig 17) This method is much stronger than the foregoing on account of the grain of each crossing the other at about 90 deg instead of 45 deg Each layer is laid at about 45 deg to the keel, and in opposite directions, so that the seams and grains cross. This method requires a very large number of fastenings, these are best arranged as shown in diagram Only the very best lumber is used because the outer skin has no fabric covering, and is therefore exposed to the sun and weather. Great care is taken in the fitting of the seams on the outside All planks are made about the same width and each plank is in one length.

GROUP 2 D, Treble Skin (Fig 18) This is seldom used in float construction but is worth describing It is very strong, but is much too heavy for the small size floats used at present. The method is the same as for double skin both diagonal, with the addition of another layer of fabric and another layer of planking over all The seams of the two inner skins are marked on the second or outer fabric Each skin is very thin and therefore requires the most careful and skillful handling

Another type of multi-skin construction is that shown in Fig 19 The layers of planking are glued and ironed together with silk between, and then instead of being riveted they are sewn together with bronze wire The wire is let in flush with the outside surface of the planking No frames are required but longitudinal stringers are used to stiffen the hull This makes a very neat and pretty job if properly and carefully executed, but is very expensive on account of the enormous amount of labor necessary

GROUPS 1 E 2-E, 3-A, Three Ply Laminated (Fig 20) This material is made up in sheets about 60 x 42 in It is made by gluing three layers of veneer together with waterproof glue under pressure The inner layer is thicker than the outer skins and sometimes they are made with all three skins equal in thickness The grain of the inner runs opposite to the outer grains, thus making a very strong and rigid construction It is invaluable in the construction of bulkheads and wing floats, planking and framing The edges are liable to splinter if not protected, and in some inferior quality of this wood the layers blister and come apart because of the glue giving way under ordinary service conditions

Wood for Planking The most common varieties are mahogany, white cedar, white pine spruce and Spanish cedar, when this latter is very carefully selected

Fastenings.—For planking of the thickness used in these floats the best fastenings are brass and copper rivets in preference to wood screws, they hold better can be driven in and have the ends turned over just as fast as a screw can be driven, and will not loosen up so readily Wood screws, if driven too hard, will strip the thread in the wood and thereby render it useless as a fastening On the other hand, screws can be used to more advantage than rivets for attaching the planking to frames and stringers

The rivets are known as Canoe rivets, varying in length from 3/8 in and upward. When long rivets are used through stringers, etc, a washer or burr is used to rivet the end over The rivets through the planking and seam strips are spaced from $1\frac{1}{2}$ to 2 in apart, the thinner the wood the closer is the spacing All wood screws used in planking have flat heads and are brass

Fin Construction (Fig 8) Fins are sometimes required in some floats for stability or additional planing surface The construction of these is very simple Capstrips as used on the floors already the fins are extended out past the float side the required distance The outer ends are notched into the fin edge stringer, which is usually made of ash and the fin frames are also notched into the stringer at their lower ends, with the upper ends attached to the stringer at the float side Over these the fin top planking is laid, usually in a fore-and-aft direction Occasionally the fins are built merely as extensions of the bottom planking, thus acting as a planing board only and not as a watertight compartment In this case the capstrips are covered with a thin plank and the outer edge is braced to the float side by short wood struts

Fabric Covering.—The material used for the covering of floats either between the layers of planking or on the outside of the planking must be very strong, light but not too thin, with sufficient body in it to hold the varnish or marine glue with which it is saturated when being applied Linen covering used on wings has been tried and found to be very suitable for the lighter type of floats, such as scout machines, but it requires proper and careful handling For the larger floats a heavier material is recommended Only the very best marine glue and the finest copal varnish are used for this work

The finishing room, where varnishing, painting, gluing, etc, are done, is kept at an even temperature of not less than 65 deg F and not more than 80 deg F It is dry and kept well ventilated, so that the fumes are quickly carried off and the process of drying facilitated

Before anything is applied to the planking it is thoroughly and carefully sandpapered to a smooth finish and then brushed off One thin coat of glue is then applied hot to the planking When in use the hot glue is maintained at the proper temperature by keeping the glue pot surrounded with boiling water or a branch pipe may be led from the steam pipe of the steam chest if this is convenient The glue itself is never allowed to boil or it will become hard and brittle when cool it must maintain its elasticity when set

The fabric is stretched in one piece wherever possible, with plenty of allowance along the edges and on the ends for gripping by hand when stretching it over the float

Before the fabric is stretched over the float is given another coat of glue, sparingly but thoroughly applied over the first This and the stretching are done very rapidly, as the fabric must be in place before the glue sets and hardens The fabric is held about one foot above the float lengthwise and is pulled taut; then while being held out on each side at the middle the center is pressed down on top of the float, worked quickly along the top to the ends the edges being kept up all around The edges are then pulled down very tightly toward the chines, taking care to pull out all puckers in the fabric Air pockets are forced out from under the fabric by rubbing firmly from the center towards the edges and ends. The fabric edges are secured by copper tacks to the chine stringers, spaced about 1 in apart When completely stretched the whole of the fabric is gone over with a hot flat iron (an electric one preferred) heated sufficiently to draw the glue through to the surface Care is taken not to overdo this ironing process, otherwise the glue would either harden or be drawn right out and thereby fail to hold the planking to the planking The glue is allowed to dry thoroughly for at least two days in the same room before painting over Three coats of paint are sufficient for the outside, the first one being thinner than the remainder

When varnish is used in place of the glue practically the same process is gone through with the exception that the first coat is applied to the bare planking just before the fabric is stretched over The fabric is given previously one or two coats of varnish and applied to the float when still wet Of course no ironing is necessary, but a coat of varnish is applied whenever the fabric is tacked down, so that it will penetrate the fabric and unite with the under coat This is allowed to dry thoroughly before the paint is applied, and each coat is dried hard before the next is put on over it

When the fabric is used between the skins of the double planking the same general method is followed The fabric in this case is not stretched so tightly as the outside covering and is tacked here and there to the inner planking to hold it in place while the outer skin is being built over

If it is found necessary to make a seam the lap is arranged so that the edge of the fabric in a transverse seam does not face forward on the outside The after edge of the foremost piece laps over the foremost edge of the after piece

(*To be continued*)

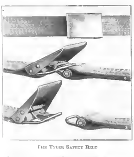
Hunting from Airplane Is Illegal

Hunting game with flying machines has been made illegal in North Carolina by a law prohibiting shooting water fowl on any of the waters of the States from an airplane.

The Tyler Safety Belt

The Tyler Safety Belt is of the quick release type, which instantly disengages the aviator at the pull of a toggle tongue buckle

The cover, or front plate of the buckle, is hinged to the rear bar of the buckle frame and the tongue is attached to the cover in such a way that it rests on the front bar of the buckle when the cover is in the closed position When the cover is opened a sufficient amount, the tongue is drawn off the front bar and drops through, positively disengaging the attached end of the belt



THE TYLER SAFETY BELT

This belt is particularly adapted for use in airplanes, airships and kite-balloons, because it is easily fastened, locks positively and cannot be interfered with by rust, ice, or heavy gloves, its operation being simple and instantaneous. Extra strain on the belt locks it more firmly, but does not interfere with its quick release feature

New Propeller Shaping Machine

"The Will to Win" has caused many ingenious machines to be designed for the purpose of speeding up the production of struts, propellers, and other pieces of airplane wood-work.

Extreme accuracy as to weight, balance and form is vital, and must be taken into consideration by the designer of any wood-working machine to make it a success on airplane parts. Especially is this true of the two, three-, or four-blade air screws For this reason many of the standard wood-working machines have proven altogether inadequate to these exacting needs.

One of the latest machines to be offered to the manufacturers of Airplane Woodwork is a Special Propeller Shaping Machine which will handle the three- or four-bladed screws, as well as the two bladed ones. It is built by the C Mattison Machine Works, Beloit, Wis

The Mattison Company has thoroughly studied the requirements of a propeller lathe, and with the co-operation of some of the biggest manufacturers in the country has perfected a machine which bids fair to revolutionize the production of propellers on account of greatly increasing capacity, as well as of much smoother cutting This works so close to finished size that very little hand work is necessary after the machining operation The manufacturer of this lathe will be pleased to supply to any one interested in the manufacture of propellers any detailed information regarding the construction and operation of the machine.

The Metric System*

By V. P. Benedict

As we know it today, that is, as the French legal standard of weights and measures, the metric system is not the complete scheme as generally proposed. Devised in the troublous years of the Revolution, the intention was to wipe out the divisions of time which belonged to the Christian Era, and to alter the immemorial standard of 360 deg. as the division of the circle.

There were to be 400 deg. of 100 min. each by which to divide the world's circumference, and 360 days to the year, with ten hours of 100 min. to the day, and it was here that the scheme "bust up." The year declined the official request to drop its odd five days, and the French people declined with thanks the ten-hour day, although the authorities tried to enforce it by all sorts of penalties.

Having succeeded in retaining the staid 24-hr. division, the 400 deg. circle went by the board because it became unworkable, since mariners found themselves with a combination of 24 hr. and 400 deg. which, divided, yields a one-eyed fraction. So they reverted to the 360 deg. division, which gives four minutes of time to one degree of the earth's rotation, or 15 deg. of rotation for each hour.

Now, although these unworkable portions of the scheme were dropped, the remaining standards, which were based on the 400 deg. circle, were retained and adopted. Four hundred degrees of 100 min. gives 40,000 min., and one-thousandth of a minute was taken as the standard for a unit measure and was called a meter. Although, as a matter of fact, not strictly accurate, the meter was meant to be one forty-millionth part of the world's circumference.

To get a unit for volumetric capacity, one tenth of a meter (about 4 in. English measure) was taken and cubed to give the liter, and taking a liter of pure water at 0 degrees temperature centigrade, the weight of it was obtained and divided into one thousand parts to give the standard unit of weight, which was called a gram.

The three units, the meter, the liter and the gram, are each uniformly divided and multiplied by tens, wherein lies all the simplicity of which adherents to the system so justifiably boast. To learn the whole system one has to memorize only about six prefixes beyond the three units, or nine items in all, and in commercial use only about half of these are called into service.

When the English schoolboy gets his 12 in. to the foot, three feet one yard business visualized, he is still in the dark when told that eight pints make one gallon, until he is shown the size of a pint or gallon measure, and so with his weights.

TABLE OF METRIC WEIGHTS AND MEASURES

	$\frac{1}{1,000}$	$\frac{1}{100}$	$\frac{1}{10}$	UNIT	10	100	1,000
	Prefix to Unit				Prefix to Unit		
Length Volume Weight	Milli	Centi	Deci	METER LITER GRAM	Deca	Hecto	Kilo

Here is a unit of length, one of volume, and one of weight, all correlated and each divided and multiplied uniformly, all of which, since the medium of correlation is pure water at a given temperature, can be corrected in any part of the world.

Now the ratio of specific gravity for any substance is taken on the basis of water at 0 degrees centigrade as the unit, and since the kilogram is the weight of a cubic decimeter of water, it is simply necessary to multiply the cubical contents of a given object in decimeters by the figure of specific gravity to obtain the weight in kilograms. Obviously, a saving over the English method where it is necessary to first find the weight of a cubic foot of water as an essential factor in the calculation, and then multiply this by the figure for specific gravity and then by the cubical contents in feet.

The metric system owes its simplicity mainly to the decimal basis on which all its sub-divisions are formed. Thus, if you have 752 mm. you have also 0.752 m., and 752 m. equals 0.752 km. With English measures, 752 in. is 62 ft. 8 in., or 20 yd. 2 ft. 8 in., and since our rules are in feet or yards, if you want to measure 752 in. you have first to do a bit of arithmetic.

Similarly if a French airplane contains 801 nuts of 22.0 g. each, the total weight (of nuts, not the plane) would be 17,622.0 g. Shift the decimal point three to the left (equal to dividing by 1000) and you get 17.622 kg., and 100 planes would contain similar nuts to the weight of 1762.2 kg., obtained by simply shifting the point.

Try it in English: 801 nuts of 1 oz. each equals 801 oz., or 50 lb. 1 oz., and you would need to work it out before you could weigh this amount. One hundred times the amount is 5006 lb. 4 oz. weighed as 2 tons 4 cwt. 2 qrs. 22 lb. 4 oz.

The pound weight was originally the weight of one pint of wheat, and the stone was the weight of a peck. The stone and peck to-day mean different values in different trades, and the whole is a most unholy chaos, to appreciate which it is only necessary to study the market reports of various commodities in the daily papers, which leave one as ignorant of what they ought to convey as do the official communiqués on airplane losses.

For we learn at school that 14 lb. make one stone, but the butcher does it with 8, which is 6 to the good, and the ounce avoirdupois can be got with lots less grains than the ounce troy. And a peck of peas or a pint of periwinkles are what you get for your money, and not what the table of weights and measures says they are.

Now whether we agree that the Metric System is preferable to our own, or, even if preferable, whether it is worth while going to the cost of changing (estimated at between 200 and 400 million pounds), the fact remains that many drawings of aero-parts and components, practically all those of Continental design and not a few of English, are dimensioned in meters and millimeters, so, those to whom these represent part of the daily grind will need to know how to tackle the problem of working in millimeters or, in the alternative, how to convert those same into English inches and fractions thereof (decimal fractions necessarily).

To handle metric-dimensioned parts satisfactorily, the best way undoubtedly is to have metric measuring instruments, get a grip of the metric system itself, which ought to take next to no time, and then go ahead metrically.

Instruments, however, are expensive and very difficult to obtain, so where these circumstances render the foregoing procedure unfeasible it becomes necessary to make conversions. For which purpose is printed herewith a Metric to English Conversion Table, which has been specially compiled to meet the particular requirements of the aircraft industry.

For small accurate parts such as engine components care must be taken to make conversions to at least the fifth place of decimals of an inch. The reason why being that the tolerance allowed is sometimes 0.00025 in. where close fits are required, and unless the fourth and fifth decimal places are accurately taken it is possible to start with an error in excess of the given allowance. When working in meters on wings and bodies two decimal places of an inch are more than sufficient.

This table is designed to be used for both meters (m.) and millimeters (mm.) since a "bus" is a big thing built up of a lot of little ones. The figures as they stand, with the point in the place shown, are for millimeters converted into inches. To convert meters into inches (which can readily be turned into feet, if necessary), the decimal point is to be taken as occuring three spaces later as shown by the slight gap between the figures.

To use the table for millimeters, the column headed 0 contains the English equivalent in inches of the even number of millimeters shown down the left side. These run from 1 to 40, and all tenths of a millimeter from 0.0 up to this figure are shown in the columns, progressing by one tenth at a time to the right. To convert a number of even mm. greater than 40, it is only necessary to adjust the decimal point as shown in the following examples:

For 6.0 mm. take the figure opposite 6 in col. headed 0.0 = 0.23622 in.

6.7 mm. take the figure opposite 6 in column headed 0.7 = 0.26378 in.

67.0 mm. take this latter figure and since 67.0 is 10 times greater than 6.7 move the point one right which multiplies the result by 10 to agree = 2.6378 in.

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[*] Excerpt from *The Aeroplane*.

278.0 mm. take figure opposite 27 in col. 0.8 and move point one to right = 10.9448 in.

2.78 mm. same figure, but point one to left (ten times less) = 0.10944 in.

275.0 mm. take 2.75 mm. and move the decimal point two places to right since it is 100 times less than the figure required, or take 27.5 mm. and move the point one place to right.

The examples show how wide is the range of the table as it stands. Every likely conversion can be handled as in the higher figures, the small fractions are rare and unnecessary, and over 400 mm. nothing more odd than 25's, 50's and 75's, which are covered by the table, are not likely to be met. It will frequently be found possible to get a double check on the conversion figure as in the case of the example given above of 275.0 mm. which can be taken either as 10 times the figure for 27.5 or 100 times the figure for 2.75.

For the conversion of metric measures other than those of length, which are covered by the table, the subjoined schedule of conversion factors will be found of use and will cover any need likely to arise. It is not always necessary to work to the full number of decimal places given, but the accuracy desired must govern the factor used.

Multiply	by	to convert into
Miles	1.6093	Kilometers.
Kilometers	0.62135	Miles
Square inches	6.4517	Square Centimeters.
Square Centimeters	0.155	Square inches.
Square feet	0.092903	Square Meters.
Square Meters	10.7639	Square feet.
Cubic inches	16.387	Cubic Centimeters
Cubic Centimeters	0.061025	Cubic inches.
Cubic feet	0.028317	Cubic Meters
Cubic Meters	35.314	Cubic feet
Cubic feet	28.317	Liters
Liters	0.035315	Cubic feet
Lbs	0.45359	Kilograms
Kilograms	2.2046	Lbs
Ounces (avoir.)	28.348	Grams
Grams	0.03527	Ounces
Lbs per Sq. inch	0.070308	Kilogs per Sq. Centimeter
Kilogs per Sq. Centimeter	14.223	Lbs per Sq. inch.
Lbs per Sq. foot	4.8827	Kilogs. per Sq. Meter
Kilogs per Sq. Meter	0.20481	Lbs per Sq. foot.

FRACTIONS

mm	inches	mm	inches
1/16	0.002461	9/16	0.022143
1/8	0.004921	5/8	0.024606
3/16	0.007382	11/16	0.027067
5/16	0.012303	13/16	0.031988
3/8	0.014764	7/8	0.034448
7/16	0.017224	15/16	0.036909

DECIMALS

mm	inches	mm	inches
0.005	0.000196	0.05	0.001968
0.01	0.000393	0.06	0.002362
0.02	0.000787	0.07	0.002755
0.03	0.001181	0.08	0.003149
0.04	0.001574	0.09	0.003543

METRIC-ENGLISH CONVERSION TABLE—METERS AND MILLIMETERS INTO INCHES

BASIC FACTOR: 1 meter equals 39.37011 inches

Meters or Millimeters	0.0	0.1	0.2	0.25	0.3	0.4	0.5	0.6	0.7	0.75	0.8	0.9
0		0.003 94	0.007 87	0.009 84	0.011 81	0.015 75	0.019 69	0.023 62	0.027 56	0.029 53	0.031 50	0.035 43
1	0.039 37	0.043 31	0.047 24	0.049 21	0.051 18	0.055 12	0.059 06	0.062 99	0.066 93	0.068 90	0.070 87	0.074 80
2	0.078 74	0.082 68	0.086 61	0.088 58	0.090 55	0.094 49	0.098 43	0.102 36	0.106 30	0.108 27	0.110 24	0.114 17
3	0.118 11	0.122 05	0.125 98	0.127 95	0.129 92	0.133 86	0.137 80	0.141 73	0.145 67	0.147 64	0.149 61	0.153 54
4	0.157 48	0.161 42	0.165 35	0.167 32	0.169 29	0.173 23	0.177 17	0.181 10	0.185 04	0.187 01	0.188 98	0.192 91
5	0.196 85	0.200 79	0.204 72	0.206 69	0.208 66	0.212 60	0.216 54	0.220 47	0.224 41	0.226 38	0.228 35	0.232 28
6	0.236 22	0.240 16	0.244 09	0.246 06	0.248 03	0.251 97	0.255 91	0.259 84	0.263 78	0.265 75	0.267 72	0.271 65
7	0.275 59	0.279 53	0.283 46	0.285 43	0.287 40	0.291 34	0.295 28	0.299 21	0.303 15	0.305 12	0.307 09	0.311 02
8	0.314 96	0.318 90	0.322 83	0.324 80	0.326 77	0.330 71	0.334 65	0.338 58	0.342 52	0.344 49	0.346 46	0.350 39
9	0.354 33	0.358 27	0.362 20	0.364 17	0.366 14	0.370 08	0.374 02	0.377 95	0.381 89	0.383 86	0.385 83	0.389 76
10	0.393 70	0.397 64	0.401 57	0.403 54	0.405 51	0.409 45	0.413 39	0.417 32	0.421 26	0.423 23	0.425 20	0.429 13
11	0.433 07	0.437 01	0.440 94	0.442 91	0.444 88	0.448 82	0.452 76	0.456 69	0.460 63	0.462 60	0.464 57	0.468 50
12	0.472 44	0.476 38	0.480 31	0.482 28	0.484 25	0.488 19	0.492 13	0.496 06	0.500 00	0.501 97	0.503 94	0.507 87
13	0.511 81	0.515 75	0.519 68	0.521 65	0.523 62	0.527 56	0.531 50	0.535 43	0.539 37	0.541 34	0.543 31	0.547 24
14	0.551 18	0.555 12	0.559 06	0.561 02	0.562 99	0.566 93	0.570 87	0.574 80	0.578 74	0.580 71	0.582 68	0.586 61
15	0.590 55	0.594 49	0.598 43	0.600 39	0.602 36	0.606 30	0.610 24	0.614 17	0.618 11	0.620 08	0.622 05	0.625 98
16	0.629 92	0.633 86	0.637 80	0.639 76	0.641 73	0.645 67	0.649 61	0.653 54	0.657 48	0.659 45	0.661 42	0.665 35
17	0.669 29	0.673 23	0.677 17	0.679 13	0.681 10	0.685 04	0.688 98	0.692 91	0.696 85	0.698 82	0.700 79	0.704 73
18	0.708 66	0.712 60	0.716 54	0.718 50	0.720 47	0.724 41	0.728 35	0.732 28	0.736 22	0.738 18	0.740 16	0.744 10
19	0.748 03	0.751 97	0.755 91	0.757 87	0.759 84	0.763 78	0.767 72	0.771 65	0.775 59	0.777 56	0.779 53	0.783 47
20	0.787 40	0.791 34	0.795 28	0.797 24	0.799 21	0.803 15	0.807 09	0.811 02	0.814 96	0.816 93	0.818 90	0.822 84
21	0.826 77	0.830 71	0.834 65	0.836 61	0.838 58	0.842 52	0.846 46	0.850 39	0.854 33	0.856 30	0.858 27	0.862 21
22	0.866 14	0.870 08	0.874 02	0.875 98	0.877 95	0.881 89	0.885 83	0.889 76	0.893 70	0.895 67	0.897 64	0.901 58
23	0.905 51	0.909 45	0.913 39	0.915 35	0.917 32	0.921 26	0.925 20	0.929 13	0.933 07	0.935 04	0.937 01	0.940 95
24	0.944 88	0.948 82	0.952 76	0.954 72	0.956 69	0.960 63	0.964 57	0.968 50	0.972 44	0.974 41	0.976 38	0.980 32
25	0.984 25	0.988 19	0.992 13	0.994 09	0.996 06	1.000 00	1.003 94	1.007 87	1.011 81	1.013 78	1.015 75	1.019 69
26	1.023 62	1.027 56	1.031 50	1.033 46	1.035 43	1.039 37	1.043 31	1.047 25	1.051 18	1.053 15	1.055 12	1.059 06
27	1.062 99	1.066 93	1.070 87	1.072 83	1.074 80	1.078 74	1.082 68	1.086 62	1.090 55	1.092 52	1.094 49	1.098 43
28	1.102 36	1.106 30	1.110 24	1.112 20	1.114 17	1.118 11	1.122 05	1.125 99	1.129 92	1.131 89	1.133 86	1.137 80
29	1.141 73	1.145 67	1.149 61	1.151 57	1.153 54	1.157 48	1.161 42	1.165 35	1.169 29	1.171 26	1.173 23	1.177 17
30	1.181 10	1.185 04	1.188 98	1.190 94	1.192 91	1.196 85	1.200 79	1.204 73	1.208 66	1.210 63	1.212 60	1.216 54
31	1.220 47	1.224 41	1.228 35	1.230 31	1.232 28	1.236 22	1.240 16	1.244 10	1.248 03	1.250 00	1.251 97	1.255 91
32	1.259 84	1.263 78	1.267 72	1.269 68	1.271 65	1.275 59	1.279 53	1.283 47	1.287 40	1.289 37	1.291 34	1.295 28
33	1.299 21	1.303 15	1.307 09	1.309 06	1.311 02	1.314 96	1.318 90	1.322 84	1.326 77	1.328 74	1.330 71	1.334 65
34	1.338 58	1.342 52	1.346 46	1.348 42	1.350 39	1.354 33	1.358 27	1.362 21	1.366 14	1.368 11	1.370 08	1.374 02
35	1.377 95	1.381 89	1.385 83	1.387 80	1.389 76	1.393 70	1.397 64	1.401 58	1.405 51	1.407 48	1.409 45	1.413 39
36	1.417 32	1.421 26	1.425 20	1.427 16	1.429 13	1.433 07	1.437 01	1.440 95	1.444 88	1.446 85	1.448 82	1.452 76
37	1.456 69	1.460 63	1.464 57	1.466 53	1.468 51	1.472 44	1.476 38	1.480 32	1.484 25	1.486 22	1.488 18	1.492 13
38	1.496 06	1.500 00	1.503 94	1.505 90	1.507 88	1.511 81	1.515 75	1.519 69	1.523 62	1.525 59	1.527 56	1.531 50
39	1.535 43	1.539 37	1.543 31	1.545 27	1.547 25	1.551 18	1.555 12	1.559 06	1.562 99	1.564 96	1.566 93	1.570 87
40	1.574 80	0.1	0.2	0.25	0.3	0.4	0.5	0.6	0.7	0.75	0.8	0.9

Book Review

THE PRINCIPLES OF AEROGRAPHY, by Prof. Alexander McAdie. (Rand McNally & Co. $3.00. Pp. 318.)

With the large increase in the number of men engaged in the flying of airplanes and dirigible balloons the science of meteorology has assumed a position of considerable interest and importance. It is important that the aviator know something of the cause of certain atmospheric phenomena. At ground schools where future aviators are given preliminary training for their work, considerable time is devoted to the study of this subject.

The number of books treating with meteorology is not large, and very few of them can be considered up to date. One of the latest is a book entitled "The Principles of Aerography," by Prof. Alexander McAdie, director of Blue Hill Observatory. The information contained in this book is given in a convenient and condensed form.

Professor McAdie's book has many features not to be found in other text-books on the subject. Among these are results of recent aerological investigations, classification of clouds according to origin rather than appearance, studies of air flow at different levels and the gradient wind, studies of ice storms, snow falls equivalent and charts for aviators.

There is a chapter devoted to the forecasting of storms and another dealing with winds. A highly interesting chapter is the one devoted to the subject of water vapor in the atmosphere, containing information on the measurement of cloud altitudes, classification of clouds, distribution and various types of clouds, wave motion in the air shown by cloud undulations and the value of clouds in the forecasting of weather changes, all of which is of interest to the aviator and aeronaut. Formation of fog, thunderstorm phenomena and rainfall are also considered.

Much information is given in the form of pictures, diagrams and charts. The cloud pictures shown, several of which were taken by Professor McAdie, are very good.

The book has about 110 illustrations, charts and diagrams, and a very complete index, which further enhance the value of this comprehensive work.

The 230 Horsepower Ago Fighting Biplane*

As regards its general lines, the Ago fighting biplane is of a strikingly unusual appearance, due mainly to the fact that the wings are tapered very pronouncedly from root to tip. This feature, so unusual in any modern machine, is decidedly disadvantageous from the manufacturing viewpoint, since it entails the separate construction of one half the ribs, no two of which are alike in one wing. The reasons which prompted the designers of the Ago to adopt the tapering wing shape become, however, evident upon examination of the interplane bracing system.

Unlike in most German two seater biplanes, which have two pairs of interplane struts on either side of the body, the Ago carries only one pair at either tip. In place of the conventional inner pair of struts there is only a single solid wire running from the upper front spar to the lower front spar, while no lift or landing wires occur between them. By doing away with the inner front interplane struts a considerable arc of fire is afforded to the gun mounted *en barbette* in the after cockpit, which can thus fire both forward and backward. Owing to the backward slope of the leading edge of the wings the outer interplane struts are farther back than they would be in a machine with straight wings and also, owing to the taper, closer together and therefore obstructing the field to a smaller extent. The small chord at the wing tips also localizes the travel of the center of pressure, so that the absence of an inner front bracing appears as a less serious defect than would seem at first sight. The four spars are, moreover, braced by inner interplane struts, one being fitted on either side of the body, in the wake of the vertical wire connecting the front spars.


Perspective Views of the Ago Fighting Biplane

The wing spars are of an interesting construction, and their section is shown in the accompanying sketches. The two flanges are glued to thin webs about (5 mm.), the whole being wrapped in fabric. No tacks or screws are employed for securing the webs to the flanges, gluing and wrapping being apparently relied upon to be sufficient for the purpose. At the points where the ribs occur a three ply distance piece is glued into the hollow spar. The rear spar, which was of slightly smaller dimensions than the front spar, was different in that its upper flange had been spindled out, otherwise the two spars were similar, also in that in both the top flange was not quite so thin as the bottom flange. The spars were constructed of what appeared to be some kind of pine, possibly Dantzig.

Where the bolt, serving as an anchorage for the wire running to the top plane occurred, the spar was strengthened by a packing piece of peculiar form. This is shown in some of our sketches, which will, we hope, help to explain it. It will be seen that the saw cuts in the ends of this distance piece leave four tapering ends, which would have the effect of cantilever beams proportioned to carry an end load, the latter being considered as the lateral load on the spar at that point. It is possible that the shape of this piece is simply the result of an attempt at stiffening the spar for a considerable distance on each side of the joint, without carrying too much weight. The vertical bolt, to which reference was made above, is *not* passed through the spar itself, but through an additional stiffening piece glued to the front face of the spar. Two horizontal bolts run through the spar, and securing on its rear face the compression strut for the internal wing bracing, are the only attachment, apart from the glue, of the packing piece to the spar proper. This arrangement is obviously weak, for a pull on the interplane wire must result in a tendency to twist the spar, placed, as it is, so far from its vertical neutral axis.

The outer interplane struts are streamline steel tubes, with a diagonal tube welded to them. In addition to this diagonal tube there is a wire running diagonally in the opposite direction, probably to ensure that the welded joints of the struts shall not have to work in tension under the changes in load caused by the travel of the centre of pressure.

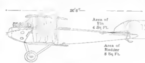
Constructionally, the ribs are of the usual I section, with webs which appear to be made of poplar, and with flanges of ash. In between the spars the webs are lightened by cutting out in the usual way. The leading edge is of pine, of a rounded V section between ribs, but left solid where the ribs are attached to it. The trailing edge is a thin lath about 1 in. wide by 3/16 in. thick.

Successive ribs are of different depth, as well as chord, owing to the fact that the spars, in addition to their convergence, are of varying depth from root to tip. Judging from the way in which the spars taper, it would appear that the end ribs are not of quite the same section as the inner ones.

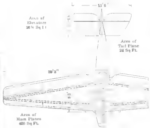
The ailerons, which have their tips at a slightly smaller angle of incidence than that of the inner ends, are hinged to a false spar slightly to the rear of the rear main spar. The leading edge of the ailerons is in the form of a steel tube partly enclosing which, and at some distance from it, is a strip of three-ply wood, which provides the requisite depth of the leading edge of the aileron. A short strip of steel, quite thin, is bent around the tube, its two ends projecting back and being accommodated in a slot in the rib. This strap is then soldered—and probably pinned, although this could not be ascertained—to the tubular leading edge.

Half way between consecutive ribs small distance pieces are tacked to the three-ply, having their free ends abutting on the surface of the tube. Another sketch shows the tube to which the inter-aileron strut is attached. The crank lever of the upper aileron has a forward projection curving up over the false spar, and dipping down in an opening between two ribs. To this projection is attached one of the aileron control cables, which runs over a pulley in the lower spar and, internally, in the lower wing to the cranks on the longitudinal rocking shaft. In plan view, the aileron crank lever is bent and runs through a rib, the clip attaching it to the inner aileron strut being similar to that at the lower aileron shown in the sketch. From this aileron crank a cable passes over another pulley in the same casing as that of the first, and hence through the lower plane to the controls. It will thus be seen that both elevating and depressing the aileron is a positive movement.

Front Elevation



Side Elevation



Plan View

The tubular leading edge of the ailerons is supported by a small bearing at the inner end, and by two clips of steel bent over the tube and bolted to the false spar at certain intervals. Thus each aileron is carried in three bearings. The outer end of the leading edge of the aileron is free. A fact which at once impresses itself on one in looking at the lateral control of the Ago, is that the point from which the aileron is actuated is very near its inner end, leaving a very large amount of the aileron unit outside, a fact which must give rise to considerable twisting stresses.

The body which is, as in the majority of German airplanes of very roomy proportions, as regards occupants' accommodation, is covered with fabric, except the front around the engine, which is covered in with three-ply, as is the floor of the body from the stern to the gunner's (rear) cockpit. From there to the nose the floor is three-ply, covered with aluminum. In section the body is rectangular, a light and comparatively flat structure forming a turtle back over the top of the main body framework. This turtle back is built up as a separate unit, and is easily detachable by means of a neat and very simple clip.

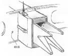
The four longerons, which are of square section, are pine, from the rear cockpit to the stern, while in front they are of ash. The struts are steel tubes, and the solid wire bracing is attached to the struts in the manner shown in one of the accompanying sketches. A small socket, apparently machined out of the solid steel bar, has holes drilled in its edges, through which the bracing wires pass. This socket is slipped over the end of the tube, which has small dents in its end to give more room for the loop of the wire, and the socket, with its strut, is secured to the longeron by a bolt passing through it, with the nut and a spring washer inside the socket, as shown in section in one of our sketches.

In front, the body bracing is in the form of diagonal steel tubes, no wires being employed. The rear cockpit is occupied by the machine gunner, who is seated on a small seat built up of a framework of steel tubing, over which is stretched canvas. This seat is so hinged and sprung that immediately the gunner stands up the seat springs into a vertical position out of his way, in case he wishes to do his shooting in a standing position. When horizontal, the seat is supported by a slanting steel tube pivoted at its lower end to the floor, and having its upper end running in a steel guide, bolted to the under side of the seat. The gun is mounted on a swiveling bracket, which, in turn, is supported on a revolving gun ring of wood, forming, in effect, a turntable, by means of which the gun may be traversed in any desired direction. A stop is provided for the gun in the form of two small frames clipped to the rear legs of the cabane, which prevents the gun barrel from traveling too far inboard.


Cable Attachment of the Ago

The pilot's seat, which is in the front cockpit, is placed on top of the main gasoline tank resting on the floor of the body.

Distance Piece of Internal Wing Bracing


Wire Attachment on Front Spar

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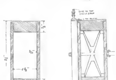
* Excerpt from *Flight*

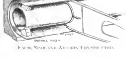
A service gasoline tank is carried in and mounted flush with the top plane just to the left of the cabane. In the corresponding opening in the upper right-hand wing is carried the radiator; the water and gasoline is led through the right and left cabane legs respectively, thus saving a certain amount of piping which would otherwise be exposed to the air.

The controls are of the usual German type, with a vertical lever terminating at the top in a double-handled grip and mounted via a universal joint, on a longitudinal rocking shaft, having at its rear end crank levers for the attachment of the aileron cables. On the machine in question no guns are mounted, but from the various fittings it appeared that there were at one time two machine guns mounted above the engine and with the usual interrupting gear for clearing the propeller blades.



CROSS SECTION OF FRONT SPAR NEAR BODY (LEFT), AND AT POINT OF ATTACHMENT OF INTERNAL WING BRACING (RIGHT)

The 230 hp. Benz engine is mounted on two longitudinal bearers, which are in turn supported from the body by three direct supports: at the rear by a sloping panel of ply-wood, in the middle by tubes sloping up from the junction of the rear panel to the lower longerons, and at the front by another panel of ply wood; this is a vertical one.



FALSE SPAR AND AILERON CONSTRUCTION

In addition to these direct supports, the engine mounting is further braced by tubes to the upper longerons, and by diagonal tubes from top to bottom longerons. The oil tank, which is comparatively small, is carried under the engine housing on the right-hand side of the crank chamber.

The tail planes are similar in construction to that of the main planes, the same form of box spars being employed. The stabilizing plane is brought to the same level as the top of the body by dropping the lower longerons somewhat after the fashion of the old Deperdussin monoplanes. A clip secures the front spar of the tail plane to the longerons, while the rear spar is attached by means of a sliding clip arrangement, which allows (not during flight) of adjusting the angle of incidence of the tail. The vertical fin, which is of tubular construction, is mounted on and moves with the tail plane. No very great amount of adjustment is, therefore, possible, as a comparatively small movement of the rear spar of the tail plane brings the rudder against the edge of the cut out portion of the fin. The rudder, which is also built of steel tubes, has no support above the stern of the body, this being difficult to obtain in conjunction with the adjustable fin. The result is that the rudder is very much overhung and does not look any too strong for its work.

The under carriage is of the Vee type, built of steel tubes stream lined with wooden fairings. The axle is slung, by means of rubber band, from the apex of the Vee, and is enclosed in a stream lined casing of aluminum. The lower half of this casing is bolted to the transverse tube of the chassis, while the upper half is hinged along this transverse tube and is allowed to move its trailing edge up and down, according to the travel of the axle. A stout wooden tail skid, sprung by means of rubber shock inside the body, has at its outer end a metal protector in the form of a hemispherical bowl bolted to the end of the skid.

BODY FITTING

DETAIL OF LOWER AILERON

S. A. E. Election

The Society of Automotive Engineers elected at its annual meeting the following officers for the ensuing year:

President—C. F. Kettering, Dayton, Ohio; *Vice Presidents*—Duval Breerolt, New York City; C. C. Hinkley, Detroit; George H. Houston, New York City; Major Fred Glover, Washington; Henry B. Sutphen, New York City, and H. R. Brate, Lakemont, N. Y. *Members of the Council*—Charles S. Crawford, Charles M. Manly and J. V. Whitbeck. *Treasurer*—Charles B. Whittelsey.

Exports of Airplanes

During October, 1917, the exports of airplanes from the United States were valued at $1,028,000 against those for the same month of the previous year, which were valued at $123,000. For the ten months ending October, 1917, the exports of airplanes were valued at $5,235,000. The exports for the same period of the previous year amounted to $3,402,000.

Development and Progress in Aviation Engines*

By the Late Henry Souther

The art of aviation and the industry of building airplanes, engines and accessories, to meet the demands of the art, is now going forward with wonderful strides. Commercial usage as well as war usage begins to attract the attention of the aeronautical engineer.

It is interesting to refer back a few years to the *Journal of The Franklin Institute*, dated Oct., 1910, and learn to appreciate the rapidity of change in the Art. Reference is made therein to a "useful load of 450 lb., including three passengers." This weight is the equivalent of about 75 gal. of gasoline, which is less than the amount required for four hours' flight of a two-passenger airplane of recent design and construction. Nearly twice this volume of gasoline is now carried with two passengers and 150 lb. additional useful load.

Reference is made to airplane flying altitude. "Prominent aviators who undertake a cross-country flight select their course with care and maintain a very high altitude." "Lambert, who ordinarily does not seek high altitudes, in soaring over Paris, was obliged to ascend to a height of more than 1600 ft." In the war zone danger is now imminent below 16,000 ft. altitude. Much flying is necessary at greater altitudes. Peaceful cross-country flying is done at what are now called safe altitudes of from 3000 to 7000 ft. From such altitudes it is probable that a suitable landing area could be reached in case of need. With a "dead" engine the angle of glide is about six to one. This means that a six miles radius circle is available for a choice of landing from an altitude of one mile.

Duration of flight is referred to as follows: "Present-day flights are no longer measured in minutes." "The hour has been exceeded by many pilots." "The airplane will enter the field of touring." All this and more is now true after a period of six years.

Aviation engine weight per horsepower delivered has not changed much, but engines are more reliable, more efficient and stronger, and heavier where experience has taught the need. The term "weight per horsepower" is a loose one. There are many parts that may or may not be considered as a part of the engine of the power plants to be included in the weight. Some twenty eight or thirty items have been found in this doubtful class. The weight of gasoline and oil consumed per hour is figured by some as an element of engine weight. It does influence the design of the airplane as a whole. It must be known. For example, the rotary, air-cooled engine, although very light, about two pounds per horsepower, is outclassed by heavier engines if the airplane must fly more than three hours. The rotary engine consumes too much gasoline and oil per horsepower-hour for long flight.

Broadly speaking, it may be said that the weight may safely vary from two to five pounds per horsepower. This will include the weight of magneto, carburetor, and wiring. Other elements of the power plant, such as water, water piping, and in the engine and the propeller, are not included.

An engine which ranks very high for speed, climbing and endurance weighs 2.4 lb. per horsepower. This engine is high strung and delicate, but very effective. Many types of engines are in practical use. There is an ever-changing idea as to the proper function for each type, and a constant shifting of opinion of one engine to another of any given type, as to the superiority. Any improvement of design, material, or workmanship may result in temporary superiority. Competition in this matter is keen. All sorts of daring expedients are tried under war pressure. The result is rapid change and rapid improvement.

The future one may not predict. The probable status six months hence is only speculation. It is certain that greater horsepowers are appearing for all types and sizes of airplanes. The result is increased speed, climb, and load-carrying capacity. There seems to be no limit to this increase except that imposed by lack of experience. This lack is being made good very rapidly just now by war conditions.

About a year ago it was thought that no more than 90 hp could be obtained from a radial rotary, air-cooled engine. One-third more has been obtained, and nearly double is now planned.

Similar improvement is being brought about, by experience, in other engines. An eight-cylinder, V-type engine now develops consistently 210 hp. Six months ago it did not function as consistently at 180 hp. There has been no radical change of design or size.

Experience has been the teacher. No internal-combustion engine of new and extreme design can be brought to a condition of practical excellence in less than a year, and often two years. Yet partially developed engines must be purchased and used or there will never be complete development.

The next and very important step is the development of organizations that can really manufacture an aviation engine or airplane, rather than build a few models, or a dozen or two nearly alike. This is a task that will easily occupy another year of consistent endeavor. At least one aviation manufacturing organization finds itself in this state of development. The building nucleus of men must be expanded into a manufacturing force. The product must be adapted to practical methods of manufacture, to existing tools, and standards, so far as possible. Otherwise no quantity production may be expected.

This has been proved many times in other industries. The aircraft industry is not different. In fact, it is astonishingly similar to the motor-car industry as found during its beginning and early growth.

Perfection would be approached by having each plant producing aviation material, as engines or airplanes, so organized and equipped as to manufacture one type only and do that well. This condition will be brought about by a consistent demand or in response to a pressing need. A proper foundation for such a development is now being laid by the same engineering body that assisted in the amazing growth of the motor-car industry—The Society of Automotive Engineers (recently Automobile, but expanded to include closely-allied industries, of which aviation is one). Its standards and engineering practices will creep into the new industry as they did into the older one.

It is difficult to discuss aviation without mentioning the Wright Brothers. They developed much knowledge of flying without an engine by gliding experiments, and then sought an engine.

At the outset of the automobile industry the power estimated as necessary was too small. Practical tests indicated that three horsepower would suffice, with a generous factor of safety. History repeated itself. Orville Wright recently stated that an eight-horsepower engine was figured as necessary. Such an engine, not to exceed 200 lb. in weight, was sought in the open market. This occurred in 1903, and none was offered that was worth considering.

The Wrights then built a four-cylinder 4- x 4-in. engine that did weigh less than 200 lb. This engine developed 12 hp. and actually flew an airplane. This engine was followed soon by a much better one that developed 30 to 35 hp. It was simple in the extreme degree. A jet nozzle in the intake pipe served to atomize the gasoline; the ignition was a low tension system, the water jackets were of sheet aluminum, the crank shaft very small in diameter, as were all other moving parts. Later engines of the same design have produced more power, are very efficient, and still being used to a limited extent.

The four-cylinder vertical engine was the first aviation engine to do real service. The airplane flown with so small an amount of power was large in wing area for the load carried, slow in speed, and sluggish in movement, judged by present standards. Such an airplane resembles the butterfly rather than the swallow. It is not like the successful fighting machine, yet will surely find place for peace usages.

Closely following this first type of engine came six-cylinder vertical and eight-cylinder V engines of 65 hp. and 75 hp. All of these were too light and frail for hard service. Minutes of flight were possible, but not hours, as now required. High-pressure lubrication to vital parts had not been developed. Valves failed because of inadequate cooling and material.

In Aug., 1908, the Wright Brothers made their first flight

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*Presented at a meeting of the Mechanical and Engineering Section of the Franklin Institute

in France. Following this date, the French engineers developed airplanes and engines of various types that embodied the fundamentals demonstrated by the Wrights, so far as the airplane was concerned. The scientist contributed much to the art by working out the theory of the art of flying. A long step forward was taken in the succeeding years.

Air-cooled engines of the radial rotating form were developed, then air-cooled and water-cooled vertical and fixed cylinders. These successive steps again repeated the steps taken by those who had developed the automobile and its engine: all were too frail and of small power. It seems safe to state that nothing as large as 100 hp. was reached or thought necessary. The Gnome radial rotating engine became most successful, and, as experience improved the skill of the aviator, the power of the engine grew gradually from 60 hp. up to 90 hp. Similarly the speed of the airplane increased up to 60 or 70 m.p.h., with slow speed or landing speed in the neighborhood of 40 m.p.h.

After a few years of this normal development, with reasonable progress relatively slow because of the enormous cost attending aircraft experiment, came the present European war. Thus began a feverish and rapid development, during which rash moves were made and long chances of an engineering character were taken. How much the demands of war have advanced the art of aviation can only be guessed, but surely as much as a generation.

As soon as the absolute necessity of aircraft as a part of a modern army was demonstrated, the production of them was forced to the limit.

Extreme types are built and flown. Planes of small area, equipped with engines of large horsepower, which must be landed at 80 m.p.h., must be used. This type is the fighting craft that seeks altitudes above the hostile projectile danger zone (about 18,000 ft.), and higher yet in order to be able to swoop down on the slower plane or upon some less skillful aviator. One hundred horsepower is no longer enough for this light and agile airplane. An engine, eight-cylinder, V type, of 150 hp., is most popular now, but with a tendency toward, and small actual use of, 200 hp., yielding a speed of 140 m.p.h. and a climb of more than 1000 ft. per minute.

The only type of airplane used for war purposes, satisfied by an engine of 100 hp. or less, is the school machine, which carries teacher and student, tandem or side by side, in the body. Thousands of these are needed and being used in Europe. It is pleasing to know that one engine being built in the United States is giving excellent satisfaction in England for this purpose.

For large war craft, battleplanes so called, more powerful engines are used. So far as known, this demand is met by engines of 250 to 350 hp. These aircraft carry bombs of explosives up to 1000 lb. in weight, and small defensive guns. They are not agile nor fast, and are defended by fast machines when possible to do so. They are the battleships of the air, defended by the torpedo boat.

To produce this power, 12 and 18 cylinders are used. The latter is of the V type, with three rows of cylinders in place of two. It is new and said to be very successful. The power is transmitted to the propeller through gears, the propeller rotating about three-fifths engine speed, at about 1000 to 1200 r.p.m. Wherever possible, gearing is avoided because of the great weight added and increased mechanical difficulties. The difficulties surrounding the propeller problem also deter. The combination of much power and high speed tends to wreck propellers. There are many elements entering into this phase of the use of large powers not yet fully understood.

An obvious means to equip an airplane with more power is to use more than one engine unit. This is done and will be done, but there is a penalty attached to the plan. The ideal disposition of weight in an airplane is to have all concentrated at the center of gravity of the entire structure. A single engine unit approaches this condition as nearly as may be. Two units mounted out in the wings, away from the center of gravity, increase the inertia, decrease the agility and maneuvering quality very much. An airplane so equipped cannot quickly turn and twist to avoid the attack of the fast machine.

There will come a time when all engineering attention is not drawn to airplanes for war purposes. Then a type of plane will be developed that will not have speed, agility, and climbing power as its principal attributes. Much less power will fill this need, and a much more normal aircraft will result. Then the multiple unit plane will have a chance to develop.

Our present aircraft development is what the racing car has been to the automobile industry—a wonderful developer for normal product and usage. In time real manufacture will begin, prices will drop and popularity increase. Engines to meet such a purpose will develop rapidly. They will, as now, be highly refined as to their essential functions, but of ordinary construction as to the non vital functions. At present the extreme of design, workmanship, and material is the aim for all parts. The art is too young to permit any other procedure.

Engine Design

The desired engine must be light, but it must be reliable. It must be capable of continuous operation at very nearly full capacity for long periods. A 20,000-ft. climb requires that everything shall be perfect.

The periods of partial use and rest are short, as for a glide. The period of level flying is from 75 per cent full power to full power, at the desire of the operator. Pursuit or flight means full power, patrol or observation duty means less, but at no time does the usage approach that of the motor-car engine. The demand is even greater than that on the marine engine, which carries a very constant load, but the marine engine may be made heavy—the aviation engine must be light.

Experience has taught that lightness must be abandoned in favor of stiffness and strength for all vital parts, such as crankshaft, crank-base, main bearings, crank-pin and piston pin bearings, and that all possible lightness must be gained by hollow construction in combination with materials most carefully chosen. Coupled with these features must be found most thorough oiling at high pressure, with oil led in a positive manner to all vital points. Much experimenting must be done, even after careful design, to arrive at a proper distribution of oil. Clearances, oil apertures and oil viscosity (hot) must be balanced.

Poppet valves must close on seats that are thoroughly cooled. Exhaust valves run cherry red hot at best. Preparations and detail of design must avoid warping and breakage.

Ignition is desired in complete duplicate for each cylinder. Magnetos must be coupled and driven in such a manner as to minimize vibration. Magneto difficulties have been of mechanical failure more than electrical, and the direct result of excessive strains due to rigid driving couplings. Wiring must be carefully conducted and fastened to prevent failure from chafing, following excessive vibration.

Spark-plugs have been the cause of more trouble and uncertainty than any other single item of aviation engine detail. The prime difficulty has been to keep the plug cool. A cool location must be provided in the design. The plug must not extend so far into the explosion chamber as to be seriously flame-swept, nor must it be deep in a hole or recess with delayed and irregular ignition. The plug itself must be gas-tight to prevent "blow by" and resulting overheat. The plug that satisfies the automobile engine will fail quickly under aviation service. This defect is more serious than appreciated, and must be guarded against. It is not easy to locate, as often assumed. Frequent change of plugs is now resorted to in the interest of reliability. Close attention to the foregoing and simple items will surely increase spark-plug life and engine reliability.

There is no more mystery about an aviation engine than about any other, when the real truth is known.

One hundred and fifteen pounds per square inch mean effective pressure is very hard to handle in connection with a light bit of construction. This pressure is needed to yield the horsepower per unit volume.

The perfect balance of moving parts is necessary. The airplane structure is very sensitive to vibration, and the occupants are seriously disturbed by an engine not functioning smoothly.

Perfect distribution of gas to give uniform explosions is a requisite. The delicate engine structure fails rapidly under the influence of irregular impulses. Carburetor parts, thin aluminum castings, wiring, gasoline tanks and piping, magneto, radiator, and propellers all fail to a serious extent in the presence of vibration.

Simplicity of design, with the smallest possible number of parts, must be the aim. Each additional screw, joint, part, or accessory increases chance of trouble in the air. The failure of such detail may cause a forced landing accident.

The fire risk may be minimized by such design of engine compartment as will promote the movement of a large volume of air in and out of the engine compartment—in such a way as to carry gasoline or gas clear of the airplane body and operator's cock-pit. Without an accumulation of gasoline the danger is small.

Engine Workmanship

The keynote of this feature is that quality must come first, cost second or last. Time must be taken to arrive at the desired accuracy or finish. Time and money must be spent to balance reciprocating parts. A limit of one per cent difference at weight for all pistons and rods in an engine is required in some cases. Exact balance of all pairs is required.

Piston rings must be tight as the result of perfect fit and bearing. Many rings must be discarded to get perfect sets. Rings good enough for motor car engines will not do the work in aviation engines.

The engine must not throw oil from any joint, valve stem, gear box, or pipe. Oil so thrown may easily cloud the goggles of the pilot. Only the closest of fits will achieve such oil-tightness.

Castings, whether aluminum or iron, must be true and of even wall thickness and of extreme lightness. Many rejections must be made to get the uniformity needed. Such rejections should be figured by those accepting engine casting orders. The best of pattern equipment and forging dies must be furnished for a comparatively small number of pieces. This adds materially to the cost of a part, but is necessary to attain workmanship of aviation engine quality.

Machine tools, fixtures, and methods must be such as to produce absolute accuracy, regardless of cost. "Quality first" should be the watchword in aviation, not "Safety first," because high quality means safety.

It is very hard to create this atmosphere among business men, superintendents, foremen, and workmen, who have always been obliged to keep in mind the cost and selling price of a product to meet competition. There is no competition in airplane engines yet. The art is too new. Performance comes first. Only the best in design, material, and workmanship will suffice.

It is possible that too much time and money are being spent, but at this time experience has not been great enough to be certain of this. Continued use over a long period of time will determine. During the youth of the industry is not the time to take a chance.

Quality and safety come first.

Engine Materials

Excellent material is required for a motor-car engine which is rarely worked to anywhere near its limit of power. Take for an example a 40-hp. engine. It runs quietly about over roads nearly level, with liberal lubricant for the work being done and consuming hardly 25 per cent (10 hp.) of its rated power.

Under comparable conditions an airplane engine uses 75 per cent of its power. Lubrication must be perfect, not nearly so.

Further, a motor-car engine of 672 cu. in. capacity is given a normal rating of 65 hp. An aviation engine of the same volume is rated at 154 hp. As a motor car engine not over 25 per cent, or 16 hp., would be ordinarily used, but as an aviation engine not less than 75 per cent, or 114 hp., would be habitually used, a ratio of about 7 to 1.

In addition, the aviation engine is built as light as possible, as about one-half the weight for a given piston displacement. Roughly speaking, this represents a punishment of material within the aviation engine fourteen times as severe as that in the motor-car engine.

The present life of an aviation engine indicates severe punishment. Up to the time when a complete overhaul is necessary this life is about fifty hours at, say, 100 m.p.h., or a total of 5000 miles. A motor-car engine runs about 25,000 miles up to the time when an overhaul repair is necessary. The speed cannot average over 25 m.p.h. This means 1000 hours' operation, or twenty times that of the aviation engine.

A severe test of endurance for the motor-car engine under shop or laboratory conditions, and where destruction of the engine is invited and closely approached, is under a development of power of about 0.15 hp. per cubic inch displacement. It is considered a fine performance for a stock motor-car engine to last 300 hours under this load. The aviation engine must do not less than this at any time and with 100 per cent score. Otherwise the engine is not a successful aviation engine.

These are rough comparisons, but they show the relative severity of work. To meet these severe conditions the very best of steel for each engine part must be used. "Best" means that money must not hinder, but high-priced steel is not sure to be best. The highest of technical skill must be utilized: first, to select the steel from chemical and physical soundness standpoints, second, to treat it in such a manner as to give the best possible endurance and the highest elastic limit consistent with the possibility of machining. Here, again, money must not be a consideration. Slow methods may be necessary to work the material.

The crank-shaft of a motor-car engine is usually so large and heavy as to permit the use of steel having an elastic limit of about 70,000 lb. per sq. in. and with a physical structure not very highly refined by heat treatment. Experience has shown this to be good practice.

The crankshaft of an airplane engine may be more in diameter, but hollow to such an extent as to demand the highest elastic limit that can be machined, say from 120,000 to 140,000 lb. per sq. in., with a reduction of area, denoting the highest refinement of grain, of 50 per cent or more.

The lighter parts of a motor-car engine, such as valve rocker arms, are given a toughening treatment for a fair forging steel, say 60,000 to 80,000 lb. per sq. in. elastic limit. The rocker arms of an airplane engine are so light and delicate as to require a fine alloy steel most carefully treated to give resistance to vibration and alternate stress. The elastic limit should also be in the neighborhood of 130,000 lb. per sq. in. This, coupled with hardness at certain points, brings additional care and expense.

A decade hence there will exist an accumulation of empirical knowledge. Extremes will then be less common or else the extreme of today will be the commonplace of the future. Experience will repeat in aviation as in many other industries and arts.

Book Review

"Dyke's Automobile Encyclopedia," A. L. Dyke, St. Louis. (Sixth Edition 1918. $3, 900 pp., 3302 ill.)

Dyke's Automobile Encyclopedia is a book well deserving the attention of the aviator and the air mechanic for, although it does not specifically deal with aviation engines it treats the subject of the internal combustion engine in such a comprehensive manner that the working of the stationary aviation engine becomes self-explanatory. The fact that the Signal Corps Aviation School at San Diego, Cal., is using this book in its course of instruction particularly recommends Dyke's Automobile Encyclopedia to the aeronautical student.

The book is not what one might term an encyclopedia in the true sense of the word, yet it is one of the most complete reference works on automobiles published, any subject, trouble, remedy or repair one can think of can be found in the 6000 lines of index.

The repair subject is, perhaps, the most interesting part of the book. There are 1189 illustrations and 154 pages devoted to this subject alone. Other instructions cover such subjects as: how to build a repair shop for home or business, and how to equip the shop from small tools to regrinding cylinders. Tire repairs, welding, battery charging, etc., are thoroughly treated. The reader is taught how to use tools, how to cut threads, how to distinguish S. A. E. and U. S. S. threads, how to use and read measuring instruments, how to solder, case harden and repair radiators, how to redesign old cars, how to straighten frames, fenders, etc.

The subject of oxy acetylene welding is very complete and fully illustrated. The instructions on ignition systems cover the entire field and in a simplified manner which anyone can understand. Instructions on the electric starting, generating and lighting are simplified with hundreds of clear illustrations of diagrams. There are 775 illustrations and 270 pages devoted to electric matters, including the storage battery and ignition subjects. In addition there are two supplements on the Ford and Packard cars, with 91 pages and 332 illustrations, a part of which are printed in two colors.

International Aircraft Standards

(Continued from last issue)

3S16 Specifications for Aluminum Alloy Sheet

GENERAL.—1. The general specifications 1G1 shall form, according to their applicability, a part of these specifications.

MATERIAL.—2. The aluminum alloy of these sheets shall be made from standard No. 1 aluminum conforming to I. A. S. B. specification 2S1. The specific gravity of the aluminum alloy shall not be greater than 2.85.

MANUFACTURE.—3. No scrap shall be used other than that produced in the manufacturer's own plants and which is of the same composition as the material specified.

WORKMANSHIP AND FINISH.—4. (a) All sheets shall be sound, flat, free from buckles, seams, discoloration or other surface defects.

(b) Any sheet may be rejected because of injurious defects or faults in manufacture at any time notwithstanding that it has previously passed inspection. It shall be returned to the manufacturer at the latter's expense. This clause shall not be taken to apply to materials fabricated after export.

PHYSICAL PROPERTIES AND TESTS.—5. The sheets may be specified in either of two tempers as desired. Specimens cut in any direction from the sheets must have the following physical properties:

Tensile Test.—(a)

	—Temper 1—		—Temper 2—	
	Pounds per square inch	Kilograms per square millimeter	Pounds per square inch	Kilograms per square millimeter
Minimum tensile strength	55,000	38.6	50,000	35.1
Minimum yield point	25,000	17.5	25,000	17.5
Minimum elongation in 2 inches	15 per cent		20 per cent	

Bend Test.—(b) Strips cut from sheets of either temper shall withstand being bent cold through an angle of 180° around a diameter equal to four times the thickness of the sheet.

SELECTION OF TEST SPECIMENS.—6. Test specimens shall be cut from a sheet selected from each 500 pounds or each individual lot submitted of less than 500 pounds.

DIMENSIONS AND TOLERANCES.—7. The tolerances upon sheets shall be those given in the table below.

Brown & Sharpe gauge	Thickness	Tolerance	Thickness	Tolerance
	Inch	Inch	Millimeters	Millimeter
10-17	0.1019-0.0453	±0.003	2.588-1.151	0.076
18-26	.0403-.0159	±.002	1.024-.404	.051

DELIVERY, SHIPPING AND PACKING.—8. The sheets shall be delivered in boxes of gross weight not greater than 220 pounds (100 kg.).

3829 Specifications for Annealed Carbon Steel Forgings and Stampings

(65,000 Pounds per Square Inch Tensile Strength)

GENERAL.—1. The general specifications 1G1 shall form, according to their applicability, a part of these specifications.

MATERIAL.—2. The steel from which these forgings or stampings are made shall conform to I. A. S. B. specification 3S2; the steel has the following composition:

Number	Carbon	Manganese	Phosphorus maximum	Sulphur maximum
1035	0.30-0.40	0.50-0.80	0.045	0.050

MANUFACTURE.—3. *Heat Treatment*.—(a) All forgings or stampings shall be annealed.

(b) Forgings or stampings which fail to meet the physical tests may, at the option of the purchaser, be reannealed.

WORKMANSHIP AND FINISH.—4. (a) The forgings and stampings must be uniform in quality, free from pipes, laps, cracks, twists, seams, and must have a workmanlike finish.

(b) A forging or stamping may be rejected at any time because of injurious defects or faults which are revealed by manufacturing operations, notwithstanding that it has previously passed inspection. Such rejected forgings or stampings shall be returned to the manufacturer at his expense. This clause shall not apply to materials fabricated after export.

PHYSICAL PROPERTIES AND TESTS.—5. (a) The heat treated forgings or stampings shall have the following physical properties:

Tensile Test.—(b)

	Pounds per square inch	Kilograms per square millimeter
Minimum tensile strength	65,000	45.7
Minimum yield point	35,000	24.6
Minimum elongation in 2 inches or proportional gauge length	25 per cent	
Minimum reduction of area	50 per cent	

Impact Test.—(c) When impact testing machines of the pendulum type are available, tests shall be carried out if required to determine the specific impact work of rupture in foot-pounds (or kilogram meters). Results markedly lower than the average for this type of material will be sufficient cause for further investigation (or reheat treatment) of the material.

Brinell Hardness Test.—(d) The Brinell hardness test shall be made after the tensile test has been met. The procedure shall be as follows:

(1) Forgings for a Prolongation for Tensile Test Specimens. A hardness test shall be made on the prolong and on the opposite end of the forging. The hardness values obtained must agree within 3 per cent. Hardness values of other forgings in the same lot must agree with the average of the two test values within 3 per cent.

(2) Forgings or Stampings Without Prolongations. Hardness tests shall be made on the forgings or stampings selected for the tensile test and must agree within 3 per cent. The hardness values of other forgings or stampings in the same lot must agree with the average of the values so obtained within 3 per cent.

(3) Forgings or Stampings from Which a Tensile Test Specimen Can Not Be Procured. A hardness test shall be made on the forged bar representing the forgings or stampings. The hardness values of the forgings or stampings in the lot must agree with that obtained on the bar within 3 per cent.

SELECTION OF TEST SPECIMENS.—6. (a) *Forgings or Stampings Weighing 6 Pounds (3.7 kg.) or Over*.—If desired, each piece may be required to have a prolongation for the tensile test. Two per cent of the forgings or stampings in each lot shall be subjected to the tensile test unless a tensile test is specified for each forging or stamping.

(b) *Forgings or Stampings Weighing Less than 6 Pounds (3.7 kg.) and of Suitable Section for Securing a Tensile Test Specimen*.—Two per cent of the forgings or stampings shall be taken for the tensile test.

(c) Forgings or stampings from which no tensile test specimen can be secured shall be represented by a bar forged from the same material and to the ruling section of the forgings or stampings in the lot. The bar must be heat treated with the lot which it represents.

(d) At least one tensile test shall be made for each lot of 50 forgings or stampings.

(e) A hardness test may be required on each forging or stamping offered. At least 25 per cent of the pieces in each lot shall be tested for hardness.

(f) All the forgings or stampings in a lot shall be heat treated at the same time and if possible shall be from the same heat of steel.

DIMENSIONS AND TOLERANCES.—7. The forgings and stampings shall conform to the dimensions on the drawings within the tolerances specified. Surfaces which are to be machined shall admit of finishing to the required dimensions without leaving trace of the original surface.

PACKING, SHIPPING AND DELIVERY.—8. Small forgings or stampings shall be boxed for shipment; the gross weight of individual boxes must not exceed 220 pounds (100 kg.). Each kind and lot of forgings or stampings shall be kept separate as inspected.

3830 Specifications for Heat-Treated Carbon Steel Forgings and Stampings

(80,000 Pounds per Square Inch Tensile Strength)

GENERAL.—1. The general specifications 1G1 shall form, according to their applicability, a part of these specifications.

MATERIAL.—2. The steel from which these forgings or stampings are made shall conform to I. A. S. B. specification 1S2; the steel has the following composition:

Number	Carbon	Manganese	Phosphorus maximum	Sulphur maximum
1035	0.30-0.40	0.50-0.80	0.045	0.050

MANUFACTURE.—3. *Heat Treatment*.—(a) Forgings or stampings should be annealed before heat treatment.

(b) Forgings or stampings which fail to meet the physical tests may, at the option of the purchaser, be reheat treated.

WORKMANSHIP AND FINISH.—4. (a) The forgings and stampings must be uniform in quality, free from pipes, laps, cracks, twists, seams, and must have a workmanlike finish.

(b) A forging or stamping may be rejected at any time because of injurious defects or faults which are revealed by manufacturing operations, notwithstanding that it has previously passed inspection. Such rejected forgings or stampings shall be returned to the manufacturer at his expense. This clause shall not apply to materials fabricated after export.

PHYSICAL PROPERTIES AND TESTS.—5. (a) The heat treated forgings or stampings shall have the following physical properties:

Tensile Test.—(b)

	Pounds per square inch	Kilograms per square millimeter
Minimum tensile strength	80,000	56.2
Minimum yield point	60,000	42.2
Minimum elongation in 2 inches or proportional gauge length	22 per cent	
Minimum reduction of area	45 per cent	

Impact Test.—(c) When impact testing machines of the pendulum type are available, tests shall be carried out if required to determine the specific impact work of rupture in foot-pounds (or kilogram meters). Results markedly lower than the average for this type of material will be sufficient cause for further investigation (or reheat treatment) of the material.

Brinell Hardness Test.—(d) The Brinell hardness test shall be made after the tensile test has been met. The procedure shall be as follows:

(1) Forgings with a Prolongation for Tensile Test Specimens. A hardness test shall be made on the prolong and on the opposite end of the forging. The hardness values obtained must agree within 3 per cent. Hardness values of other forgings in the same lot must agree with the average of the two test values within 3 per cent.

(2) Forgings or Stampings Without Prolongations. Hardness tests shall be made on the forgings or stampings selected for the tensile test and must agree within 3 per cent. The hardness values of other forgings or stampings in the same lot must agree with the average of the values so obtained within 3 per cent.

(3) Forgings or Stampings from Which a Tensile Test Specimen Can Not Be Procured. A hardness test shall be made on the forged bar representing the forgings or stampings. The hardness values of the forgings or stampings in the lot must agree with that obtained on the bar within 3 per cent.

SELECTION OF TEST SPECIMENS.—6. (a) *Forgings or Stampings Weighing 6 Pounds (3.7 kg.) or Over*.—If desired, each piece may be required to have a prolongation for the tensile test. Two per cent of the forgings or stampings in each lot shall be subjected to the tensile test unless a tensile test is specified for each forging or stamping.

(b) *Forgings or Stampings Weighing Less Than 6 Pounds (3.7 kg.) and of Suitable Section for Securing a Tensile Test Specimen*.—Two per cent of the forgings or stampings shall be taken for the tensile test.

(c) Forgings or stampings from which no tensile test specimen can be secured shall be represented by a bar forged from the same material and to the ruling section of the forgings or stampings in the lot. The bar must be heat treated with the lot which it represents.

(d) At least one tensile test shall be made for each lot of 50 forgings or stampings.

(e) A hardness test may be required on each forging or stamping offered. At least 25 per cent of the pieces in each lot shall be tested for hardness.

(f) All the forgings or stampings in a lot shall be heat treated at the same time and if possible shall be from the same heat of steel.

DIMENSIONS AND TOLERANCES.—7. The forgings and stampings shall conform to the dimensions on the drawings within the tolerances specified. Surfaces which are to be machined shall admit of finishing to the required dimensions without leaving trace of the original surface.

PACKING, SHIPPING AND DELIVERY.—8. Small forgings or stampings shall be boxed for shipment; the gross weight of individual boxes must not exceed 220 pounds (100 kg.). Each kind and lot of forgings or stampings shall be kept separate as inspected.

3831—Specifications for Heat Treated Carbon Steel Forgings and Stampings

(95,000 Pounds per Square Inch Tensile Strength)

GENERAL.—1. The general specifications 1G1 shall form according to their applicability a part of these specifications.

MATERIAL.—2. The steel from which these forgings or stampings are made shall conform to I. A. S. B. specifications 3S45; the steel shall have the following composition:

Number	Carbon	Manganese	Phosphorus, maximum	Sulphur maximum
1045	0.40-0.50	0.50-0.80	0.045	0.050

MANUFACTURE.—3. *Heat Treatment*.—(a) Forgings or stampings should be annealed before heat treatment.

(b) Forgings or stampings which fail to meet the physical tests may, at the option of the purchaser, be reheat treated.

WORKMANSHIP AND FINISH.—4. (a) The forgings and stampings must be uniform in quality, free from pipes, laps, cracks, twists and seams, and must have a workmanlike finish.

(b) A forging or stamping may be rejected at any time because of injurious defects or faults which are revealed by manufacturing operations, notwithstanding that it has previously passed inspection. Such rejected forgings or stampings shall be returned to the manufacturer at his expense. This clause shall not apply to materials fabricated after export.

PHYSICAL PROPERTIES AND TESTS.—5. (a) The heat-treated forgings or stampings shall have the following physical properties:

Tensile Test.—(a)

	Pounds per square inch	Kilograms per square millimeter
Minimum tensile strength	95,000	66.8
Minimum yield point	70,000	49.2
Minimum elongation in 2 inches or proportional gauge length	18 per cent.	
Minimum reduction of area	45 per cent.	

Impact Test.—(c) When impact testing machines of the pendulum type are available tests shall be carried out if required to determine the specific impact work of rupture in foot pounds (or kilogram meters). Results markedly lower than the average for this type of material will be sufficient cause for further investigation (or reheat treatment) of the material.

Brinell Hardness Test.—(d) This test shall be made after the tensile test has been met. The procedure shall be as follows:

(1) Forgings with a Prolongation for Tensile Test Specimens. A hardness test shall be made on the prolong and on the opposite end of the forging. The hardness values obtained must agree within 3 per cent. Hardness values of other forgings in the same lot must agree with the average of the two test values within 3 per cent.

(2) Forgings or Stampings without Prolongations. Hardness tests shall be made on the forgings or stampings selected for the tensile test and must agree within 3 per cent. The hardness values of other forgings or stampings in the same lot must agree with the average of the values so obtained within 3 per cent.

(3) Forgings or Stampings from Which a Tensile Test Specimen Can Not Be Procured. A hardness test shall be made on the forged bar representing the forgings or stampings. The hardness values of the forgings or stampings in the lot must agree with that obtained on the bar within 3 per cent.

SELECTION OF TEST SPECIMENS.—(6) *Forgings or Stampings Weighing 6 Pounds (3.7 kg.) or Over*.—(a) If desired each piece may be required to have a prolongation for the tensile test. Two per cent of the forgings or stampings in each lot shall be subjected to the tensile test unless a tensile test is specified for each forging or stamping.

(b) *Forgings or Stampings Weighing Less Than 6 Pounds (3.7 kg.) and of Suitable Section for Securing a Tensile Test Specimen*.—(b) Two per cent of the forgings or stampings shall be taken for the tensile test.

(c) Forgings or stampings from which no tensile test specimen can be secured, shall be represented by a bar forged from the same material and to the ruling section of the forgings or stampings in the lot. The bar must be heat treated with the lot which it represents.

(d) At least one tensile test shall be made for each lot of 50 forgings or stampings.

(e) A hardness test may be required on each forging or stamping offered. At least 25 per cent of the pieces in each lot shall be tested for hardness.

(f) All the forgings or stampings in a lot shall be heat treated at the same time, and if possible shall be from the same heat of steel.

DIMENSIONS AND TOLERANCES.—7. The forgings and stampings shall conform to the dimensions on the drawings within the tolerances specified. Surfaces which are to be machined shall admit of finishing to the required dimensions without leaving trace of the original surface.

PACKING, SHIPPING AND DELIVERY.—8. Small forgings or stampings shall be boxed for shipment; the gross weight of individual boxes must not exceed 220 pounds (100 kg.). Each kind and lot of forgings or stampings shall be kept separate as inspected.

3N10—Specifications for Babbitt Metal for Bronze-Backed Bearings

GENERAL.—1. The general specifications, 1G1, shall form according to their applicability a part of these specifications.

MATERIAL.—2. The composition of the material shall be as follows:

Constituent	Desired	Allowable variation
	Per cent	Per cent
Tin	91.00	90-92
Antimony	4.50	4-5
Copper	4.50	4-5
Lead, maximum	.20	

SAMPLE FOR ANALYSIS.—3. (a) The inspector shall select one ingot from each lot of 25. The manufacturer shall melt this ingot in a clean ladle and cast therefrom one or more sample bars 8 in. long, 1 in. wide and not more than ¼ in. thick.

(b) Saw cuts shall be made in each sample bar as shown in the diagram below. The cuttings shall be thoroughly mixed and must be free from iron and dust. Samples for analysis shall be taken from the mixed cuttings.

MANUFACTURE.—4. (a) The babbitt metal shall be made from lake or electrolytic copper conforming to the I. A. S. B. specification 3S2 and from the best commercial grades of tin and antimony.

(b) No scrap shall be used other than that produced in the manufacturers' own plants and which is of the same composition as the material specified.

3832—Specifications for Heat-Treated Alloy Steel Forgings and Stampings

(100,000 Pounds per Square Inch Tensile Strength.)

GENERAL.—1 The general specifications, 1G1 shall form according to their applicability, a part of these specifications

MATERIAL.—2 The steel from which these forgings or stampings are made shall conform to I. A. S. B. specification 383.

MANUFACTURE.—3. *Heat Treatment*—(a) Forgings or stampings should be annealed before heat treatment

(b) Forgings or stampings which fail to meet the physical tests may at the option of the purchaser be reheat treated

WORKMANSHIP AND FINISH.—4 (a) The forgings and stampings must be uniform in quality, free from pipes, laps, cracks, twists and seams and must have a workmanlike finish.

(b) A forging or stamping may be rejected at any time because of injurious defects or faults which are revealed by manufacturing operations, notwithstanding that it has previously passed inspection. Such rejected forgings or stampings shall be returned to the manufacturer at his expense. This clause shall not apply to materials fabricated after export.

PHYSICAL PROPERTIES AND TESTS.—5 (a) The heat treated forgings or stampings shall have the following physical properties

Tensile Test.—(b)

	Pounds per square inch	Kilograms per square millimeter
Minimum tensile strength	100,000	70 3
Minimum yield point	80 000	56 2
Minimum elongation in 2 inches at proportional gauge length	20 per cent.	
Minimum reduction of area.	50 per cent	

Impact Test.—(c) When impact-testing machines of the pendulum type are available tests shall be carried out if required to determine the specific impact work of rupture in foot-pounds (or kilogram meters). Results markedly lower than the average for this type of material will be sufficient cause for further investigation (or reheat treatment) of the material

Brinell Hardness Test.—(d) The Brinell hardness test shall be made after the tensile test has been met. The procedure shall be as follows

(1) Forgings with a Prolongation for Tensile Test Specimens. A hardness test shall be made on the prolong and on the opposite end of the forging. The hardness values obtained must agree within 3 per cent. Hardness values of other forgings in the same lot must agree with the average of the two test values within 3 per cent

(2) Forgings or Stampings without Prolongations. Hardness tests shall be made on the forgings or stampings selected for the tensile test and must agree within 3 per cent. The hardness values of other forgings or stampings in the same lot must agree with the average of the values so obtained within 3 per cent

(3) Forgings or Stampings from which a Tensile Test Specimen Can Not Be Procured. A hardness test shall be made on the forged bar representing the forgings or stampings. The hardness values of the forgings or stampings in the lot must agree with that obtained on the bar within 3 per cent

SELECTION OF TEST SPECIMENS.—6 *Forgings or Stampings Weighing 6 Pounds (3 7 kg.) or Over*.—(a) If desired each piece may be required to have a prolongation for the tensile test. Two per cent of the forgings or stampings in each lot shall be subjected to the tensile test, unless a tensile test is specified for each forging or stamping.

Forgings or Stampings Weighing Less than 6 Pounds (3 7 kg.) and of Suitable Section for Securing a Tensile Test Specimen.—(b) Two per cent of the forgings or stampings shall be taken for the tensile test

(c) Forgings or stampings from which no tensile test specimen can be secured shall be represented by a bar forged from the same material and to the ruling section of the forgings or stampings in the lot. The bar must be heat treated with the lot which it represents.

(d) At least one tensile test shall be made for each lot of 50 forgings or stampings.

(e) A hardness test may be required on each forging or stamping offered. At least 25 per cent of the pieces in each lot shall be tested for hardness.

(f) All the forgings or stampings in a lot shall be heat treated at the same time and if possible shall be from the same heat of steel

DIMENSIONS AND TOLERANCES.—7 The forgings and stampings shall conform to the dimensions on the drawings within the tolerances specified. Surfaces which are to be machined shall admit of finishing to the required dimensions without leaving trace of the original surface

PACKING, SHIPPING, AND DELIVERY.—8 Small forgings or stampings shall be boxed for shipment; the gross weight of individual boxes must not exceed 220 pounds (100 kg.). Each kind and lot of forgings or stampings shall be kept separate as inspected

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3833—Specifications for Heat-Treated Alloy Steel Forgings and Stampings

(120,000 Pounds per Square Inch Tensile Strength.)

GENERAL.—1 The general specifications 1G1, shall form, according to their applicability, a part of these specifications

MATERIAL.—2 The steel from which these forgings or stampings are made shall conform to I. A. S. B. specification 384

MANUFACTURE.—3 *Heat Treatment*.—(a) Forgings or stampings should be annealed before heat treatment

(b) Forgings or stampings which fail to meet the physical tests may at the option of the purchaser, be reheat treated

WORKMANSHIP AND FINISH.—4 (a) The forgings and stampings must be uniform in quality, free from pipes, laps, cracks, twists and seams and must have a workmanlike finish

(b) A forging or stamping may be rejected at any time because of injurious defects or faults which are revealed by manufacturing operations notwithstanding that it has previously passed inspection. Such rejected forgings or stampings shall be returned to the manufacturer at his expense. This clause shall not apply to materials fabricated after export

PHYSICAL PROPERTIES AND TESTS.—5 (a) The heat treated forgings or stampings shall have the following physical properties

Tensile Test.—(b)

	Pounds per square inch	Kilograms per square millimeter
Minimum tensile strength	120 000	84 3
Minimum yield point	95 000	66 8
Minimum elongation in 2 inches at proportional gauge length	15 per cent	
Minimum reduction of area.	50 per cent.	

Impact Test.—(c) When impact testing machines of the pendulum type are available, tests shall be carried out if required to determine the specific impact work of rupture in foot pounds (or kilogram meters). Results markedly lower than the average for this type of material will be sufficient cause for further investigation (or reheat treatment) of the material

Brinell Hardness Test.—(d) The Brinell hardness test shall be made after the tensile test has been met. The procedure shall be as follows

(1) Forgings with a Prolongation for Tensile Test Specimens. A hardness test shall be made on the prolong and on the opposite end of the forging. The hardness values obtained must agree within 3 per cent. Hardness values of other forgings in the same lot must agree with the average of the two test values within 3 per cent

(2) Forgings or Stampings without Prolongation. Hardness tests shall be made on the forgings or stampings selected for the tensile test and must agree within 3 per cent. The hardness values of other forgings or stampings in the same lot must agree with the average of the values so obtained within 3 per cent

(3) Forgings or Stampings from which a Tensile Test Specimen Can Not Be Procured. A hardness test shall be made on the forged bar representing the forgings or stampings. The hardness values of the forgings or stampings in the lot must agree with that obtained on the bar within 3 per cent.

SELECTION OF TEST SPECIMENS.—6. *Forgings or Stampings Weighing 6 Pounds (3.7 kg.) or Over*.—(a) If desired each piece may be required to have a prolongation for the tensile test. Two per cent of the forgings or stampings in each lot shall be subjected to the tensile test, unless a tensile test is specified for each forging or stamping

Forgings or Stampings Weighing Less than 6 Pounds (3 7 kg.) and of Suitable Section for Securing a Tensile Test Specimen.—(b) Two per cent of the forgings or stampings shall be taken for the tensile test

(c) Forgings or stampings from which no tensile test specimen can be secured, shall be represented by a bar forged from the same material and to the ruling section of the forgings or stampings in the lot. The bar must be heat treated with the lot which it represents

(d) At least one tensile test shall be made for each lot of 50 forgings or stampings

(e) A hardness test may be required on each forging or stamping offered. At least 25 per cent of the pieces in each lot shall be tested for hardness

(f) All the forgings or stampings in a lot shall be heat treated at the same time and if possible shall be from the same heat of steel

DIMENSIONS AND TOLERANCES.—7 The forgings and stampings shall conform to the dimensions on the drawings within the tolerances specified. Surfaces which are to be machined shall admit of finishing to the required dimensions without leaving trace of the original surface

PACKING, SHIPPING, AND DELIVERY.—8 Small forgings or stampings shall be boxed for shipment, the gross weight of individual boxes must not exceed 220 pounds (100 kg.). Each kind and lot of forgings or stampings shall be kept separate as inspected

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Sheet Metal Workers' Tools and Machines

Descriptions and illustrations of tinsmiths' and sheet metal workers' tools and machines as they apply to the needs of the manufacturers of light metal parts of airplanes, are given in Catalog 16 A of the Peck Stow & Wilcox Co. Southington, Conn.

It contains 270 pages, is attractively bound and indexed and has more than 300 illustrations and much valuable data.

Digest of the Foreign Aeronautical Press

Flying (London), December 12, 1917

Traffic in the Clouds. By Claude D. Farmer.—As a passenger vehicle the airplane, and for that matter, the airship is a perfectly defensible proposition. No doubt can exist in any but the more sceptical minds that where speed is a *sine qua non* the air forms the solution of all the fretful delays and congestions of land travel and of the loss of time inherent to sea voyages. The development of a routine service of airplanes, even though the fares charged would be in excess of the first-class train fare of normal times, must lead to a remunerative source of traffic for the reason that there are many to whom the twenty-four hours of the day are all too short.

We need not, however, labor the point of passenger traffic by air. The proposition which we have set out to study is not that of human but of material cargoes. Here the future is neither so promising nor so easy to forecast.

The whole matter, in fact, turns upon the question of whether commerce involves any class of goods traffic which can be conveyed, let us say, more efficiently by the new system of transport than by the existing railway and steamship systems. The limiting condition is the fact that only certain classes of merchandise by reason of their bulk or weight, the latter factor being the determining one, lend themselves to conveyance by air. Of lighter than air machines, the L33 type of Zeppelin should allow useful loads—i. e. cargoes—up to five tons being borne. The maximum average speed attained by the Zeppelins is about 60 miles per hour. This is fast travel compared with what the goods train maintains as its average speed, and with the speed of the merchant ship. But at what cost is the consignee of the goods to pay for this speed? An initial capital investment of fully a quarter of a million sterling must be made good from the freight charges. Then there are the running expenses due to the fuel and oil consumption. To transport the five tons of goods over 1,000 miles in $16\frac{1}{2}$ hours no less than 1,300 gallons of gasoline will be consumed. Now what, on the other hand, have the railway companies to offer? If speed be no object, there is the goods train, but since aerial locomotion makes its appeal on the grounds of speed, we must turn to the case of the passenger train in which five tons of parcels could be carried at almost the same speed and certainly far more cheaply than by the Zeppelin. The freight cost is much lower than the minimum rate at which the airship could compete upon a profit making basis, even supposing the efficiency of the gasoline engine to be enormously increased in the future. Marine transport is heavily at a disadvantage as regards speed, but against this there is the fact that it implies a cost per ton mile even lower than that for railway goods traffic.

The case for the large airplane is more hopeful, though scarcely promising enough to make one sanguine as to its utility in the immediate future. The best load carrying performance to date is probably about $2\frac{1}{2}$ tons. A speed of 80 miles per hour may be assumed feasible with an engine power of 1000 h.p. The capital cost of two such airplanes equivalent in carrying power to one Zeppelin would be but a fraction of the cost of one large airship. A saving would also be effected in aerodrome accommodation, not to mention the gain in utility for the conveyance of small packages presented by two airplanes as individual units contrasted with the single Zeppelin.

But even though the airplane is better than the airship on the score of cheapness of production per unit volume of traffic the freight charge per ton mile must still be higher than the prevailing parcels rate on the railways. The gain in speed, especially when one considers the time spent in collecting and distributing goods in large towns is not marked; certainly it is not decisive enough to compensate for the additional cost of transit, nor to justify traders in abandoning the established institution of the railways. Nor is the permanent way of the air likely to compete for many a long year with the mercantile marine, unless it be that international finance become so accelerated and intensified after the war as to demand the transference of specie from country to country in the minimum of time.

This last is, however, a special type of traffic. It is, in fact, in the administrative work of modern business rather than in the normal demands of material transport that one is tempted to forecast a lucrative field for the use of aircraft.

In commerce as in national government, there arise many classes of communication, the rapid transference of which from one office or one country to another implies extended business. Among men separated by hundreds of miles there are often multifarious papers to be signed and reports to be read with the least possible delay, and letters which it is not convenient to transmit by telegraph even when coded. It is for such urgent correspondence as this, smaller in volume than the usual post-bag for which railway transit is the cheaper system, that an aerial mail service might well be instituted. As a State enterprise the scheme could be organized to give such a service as frequent, and decidedly faster, than that afforded by the existing mail trains. Large firms might, indeed, under conditions where their business covered many parts of the country, combine a private mail service of their own with means for rapidly conveying members of their staff from one place of business to another. An aerial post between England and the Continent, and eventually between London and New York, would be an enterprise of incalculable value, as is evident when one realizes that the five days' voyage across the Atlantic could by air be made in two days or less. Such a performance as the latter is already under consideration as a practical possibility.

Flight (London), Dec. 6, 1917

The Danger of Over-Standardisation (Editorial).—We are glad to hear that the Air Board has addressed a communication to the Aircraft Production Board of the United States on the subject of the danger arising out of over-standardization of aircraft, a subject to which attention has frequently been directed in these pages. As to the usefulness of standardization within limits there can be no two opinions, but it is quite possible for the keenness for output to work to our great disadvantage. In considering the problems attending the construction of aircraft, we have to keep it well before us that the design of today is likely to be rendered hopelessly obsolete by that of tomorrow, and it is thus folly of the worst description to put all our eggs into the one basket. We are not implying that that is the policy which is being pursued in America, but we do think there is a danger that our Allies' enthusiasm for manufacturing efficiency and huge outputs might tend to lead them a little astray. Evidently this view is shared to some extent by our own authorities, and hence the warning which is said to have been given. No undue importance need be attached to the fact that the Air Board has thought it necessary to give America what may really be called a friendly tip. There is certainly no divergence of opinion between us and our Allies regarding the future of war in the air. All that has happened is that a little advice, born of our greater experience of war, has been tendered by the one and accepted by the other in the spirit of absolute friendship.

The Aeroplane (London), Dec 5, 1917

The Civil Aerial Transport Committee.—On Dec. 3 in reply to Mr Pemberton Billing who asked to be informed about the progress made by the Civil Aerial Transport Committee, Mr Bonar Law, Prime Minister of Great Britain stated in the House of Commons the following

"During the last six months Lord Northcliffe, who was originally chairman, Major-General Brancker, Lord Montagu of Beaulieu, Mr Claude Johnson and Mr Tyson Wilson have left the Committee in consequence of other duties, while Sir G Perley, Major General McCay, and Sir Mackenzie Chalmers have been added to the main Committee to represent the Dominion of Canada, the Commonwealth of Australia, and the Home Office respectively. Sir E. Morris, the Prime Minister of Newfoundland, is also joining the Committee. In addition, a number of gentlemen with special knowledge of the particular subjects of inquiry have been co-opted on the various sub-committees.

"It is proposed to continue the Committee in existence till it has presented its report."

News of the Fortnight

Department of Munitions Is Proposed

On Jan 4 Senator George E Chamberlain, of Oregon introduced in the Senate a bill (S 3311) to create a Department of Munitions, and on Jan 7, Congressman William T Borland of Missouri introduced a duplicate bill in the House of Representatives

Discussing the intentions of the measure, Senator George E Chamberlain of Oregon, Chairman of the Committee on Military Affairs, said, "The bill is intended to increase and expedite the supply of munitions of war One great trouble with the war establishment as disclosed by the pending investigation has been a lack of co-ordination and the seeming impossibility of getting rid of circuitous methods of doing business. Until there can be co-ordination and methods more direct the United States will be groping in the dark for many months before we can place ourselves in proper fighting trim

"This measure places all jurisdiction over munitions of war, which is defined at length in the bill and covering everything in one person, known as the Secretary of Munitions, subject to the direction, of course, of the President

"It co-ordinates all of the bureaus cuts red tape, does away with useless decisions which had tended only to hamper direct action, and gets to the heart of the whole situation I believe if Congress can see its way to the enactment of this measure, and the proper man is placed at the head of the department of munitions, America will soon be occupying its proper place at the battle front It will be noted that the measure is only in force during the continuance of the war, which brings it into existence"

Senator Chamberlain in reply to the questions of a representative of AVIATION AND AERONAUTICAL ENGINEERING stated in effect that his bill is designed to cover both the purchase and supply of airplanes and materials, the Liberty engine and whatever goes into their manufacture As the Senator emphatically put it, "It covers everything"

The opinion in some quarters is that should this bill become a law, the powers of the Aircraft Board will be greatly curtailed, and that perhaps the Board will be entirely abolished It is understood that this bill will be strongly pushed in the Senate for early passage

Asks $50,000,000 for Aeronautic Bases

The expenditure of $50,000,000 for the construction of aeronautic bases in the United States and its territorial possessions is proposed in a report sent to Congress by Secretary of War Baker The report contains an outline which the Secretary has in mind, and suggests that further information would be given to Congress in closed hearings of committees which handle the proposed appropriations

The report does not disclose where it is proposed to locate the new bases. Here is the allotment suggested by Secretary Baker in disposing of the $50,000,000

$24,000,000 for sixteen aeronautic stations in the United States.

$3,500,000 for twenty balloon stations in the United States
$4,420,000 for aviation bases in Hawaii
$5,420,000 for aviation bases in Panama
$12 008,000 for equipment of these various bases

Secretary Baker said no decision has been reached as to the locations.

S. A. E to Discuss Motor Boats

A special meeting of the Society of Automotive Engineers for the consideration of subjects relating to motor boat matters will be held in New York on Friday evening, Jan 25, during the week of the Annual Motor Boat Show, scheduled for Jan 19-26 There will be afternoon and evening sessions, with a dinner sandwiched in between The first session will be opened on Friday afternoon, Jan 25 This meeting will be held at the S A E headquarters 29 West 39th Street The dinner, and the evening session will be held at the Automobile Club of America, 247 West 54th Street

Two Officers Made Military Aviators

Lieut Cols. Virginius E Clark and William L Patterson have been recently rated as military aviators in the Aviation Section, Signal Corps of the United States Army

Report of Council of National Defense

The annual report of the Council of National Defense covers its activities from its inception to the close of the fiscal year ending June 30, 1917 The permanent organization of the Council was not effected until March 3, of last year.

The complete report has not as yet been issued from the Government printing office, but in the summary prepared for the press, the policy of the Aircraft Production Board which has been superseded by the Aircraft Board, is of special interest to manufacturers of airplanes and aeronautical engines. The summary follows

AIRCRAFT PRODUCTION BOARD

"The work of the Aircraft Board resolved itself into two main divisions equipment for training purposes in this country and equipment for combat work in France It was found that a very satisfactory training plane and motor had been developed by an American company, which had been tested and found satisfactory both by England and Canada

"It was in the development of the program of combat, reconnaissance and bombing planes that the major difficulties were encountered In all these forms of machine, the lack of previous American experience made it seem necessary to depend to a large extent on designs developed in the Allied countries or adaptations from these designs. In the production of engines there appeared to be an insuperable obstacle to produce foreign engines and translating them in the methods of American shop practice

"It was this consideration that led to development of the composite international design known as the 'Liberty Engine,' so constructed and with its parts so standardized that it lends itself easily to quantity production with American shop methods

"Among other features of the board's work covered in the report, are the progressive development of the manufacturing resources of the country capable of being adapted to the manufacture of airplanes and the steps taken to convert them to that work, the general policy adopted of relying mainly on relatively few highly organized and manifestly capable establishments rather than scattering orders for planes and separate parts among a large number of small shops, this decision being accompanied by a careful inventory of the facilities for manufacture, particularly automobile plants the steps taken to relieve the shortage in satins and linen, and the recommendations made as to forms of contract, the elimination of foreign royalties and other general assistance in developing business and industrial policy"

Airplane Mail Service

The act making appropriations for the service of the Post Office Department for the fiscal year ending June 30, 1919, and for other purposes (H R 7237), was passed by the House of Representatives on Dec 14 It is now under consideration by the Committee on Post Offices and Post Roads of the Senate.

An item under the appropriation for the office of the second assistant postmaster general provides $1,185,000 for inland transportation by steamboat or other power boat routes or by airplanes The section reads

'Out of this appropriation the Postmaster General is authorized to expend not exceeding $100,000 for the purchase, operation, and maintenance of airplanes for an experimental airplane mail service between such points as he may determine"

Government Is Using Motor Plant

A portion of the machinery and plant of the General Vehicle Co of Long Island City, N Y, which is being utilized to turn out the Gnome monosoupape airplane engine, was recently taken over by the Government The company makes the following announcement

"With respect to certain rumors regarding the General Vehicle Co, Inc, it may be authoritatively stated that while a considerable portion of the Long Island City plant will be devoted to other work than manufacture of electric trucks, the General Vehicle Co, as well as its manufacture of electric trucks will continue utilizing such portions of the Long Island City plant as may be necessary for the purpose of continuing its business of nearly seventeen years."

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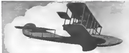

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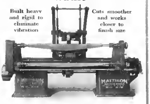

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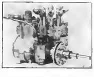

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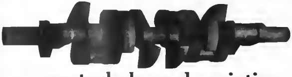

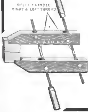
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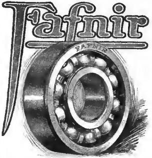
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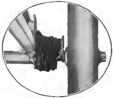

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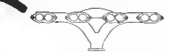

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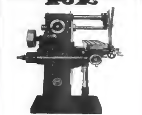

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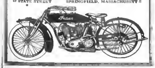

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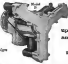
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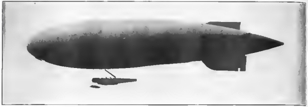

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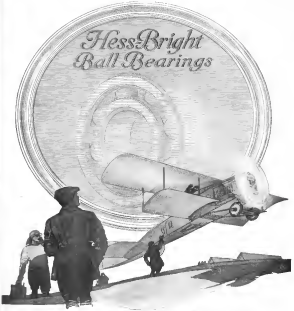

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